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Giokas

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(54) SYSTEMS AND METHODS FOR SELF-TUNING NETWORK INTRUSION DETECTION AND PREVENTION

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H04L 29/06	(2006.01)
G06F 12/14	(2006.01)
G06F 12/16	(2006.01)

(52) **U.S. Cl.**
CPC ***H04L 63/1433*** (2013.01); ***H04L 63/1416*** (2013.01); ***H04L 63/1441*** (2013.01)

(58) **Field of Classification Search**
None
See application file for complete search history.

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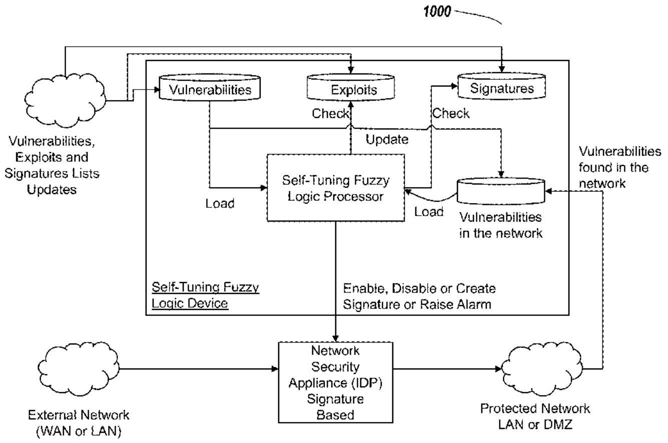
(57) ABSTRACT

Systems and method of the present disclosure are directed to a network security tool. In some embodiments, the tool identifies a current vulnerability of a private network. The tool can determine a signature of an attack configured to exploit the current vulnerability. The tool can comparing the signature with active and inactive signatures stored in a signature repository. The tool can compare the signatures to identify an inactive signature corresponding to the signature of the attack configured to exploit the current vulnerability. The tool can automatically activate, responsive to the comparison, the identified inactive signature. The tool can use the activated signature to identify an exploit based on data packets received via the private network.

20 Claims, 14 Drawing Sheets


1000
Vulnerabilities
Exploits
Signatures
Check
Check
Update
Vulnerabilities, Exploits and Signatures Lists Updates
Self-Tuning Fuzzy Logic Processor
Load
Load
Vulnerabilities in the network
Vulnerabilities found in the network
Self-Tuning Fuzzy Logic Device
Enable, Disable or Create Signature or Raise Alarm
Network Security Appliance (IDP) Signature Based
External Network (WAN or LAN)
Protected Network LAN or DMZ

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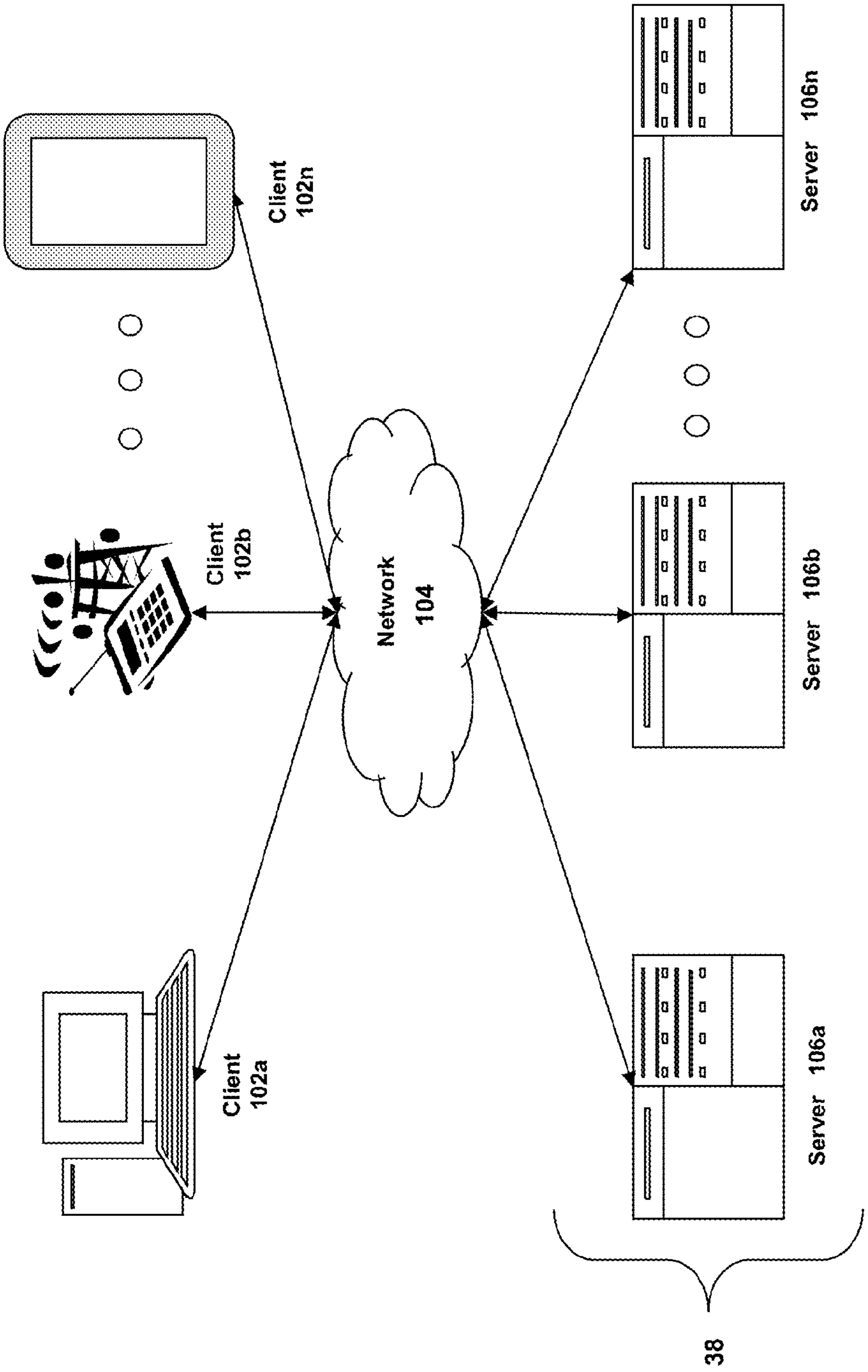
Client 102a
Client 102b
Client 102n
Network 104
Server 106a
Server 106b
Server 106n
38

Fig. 1A

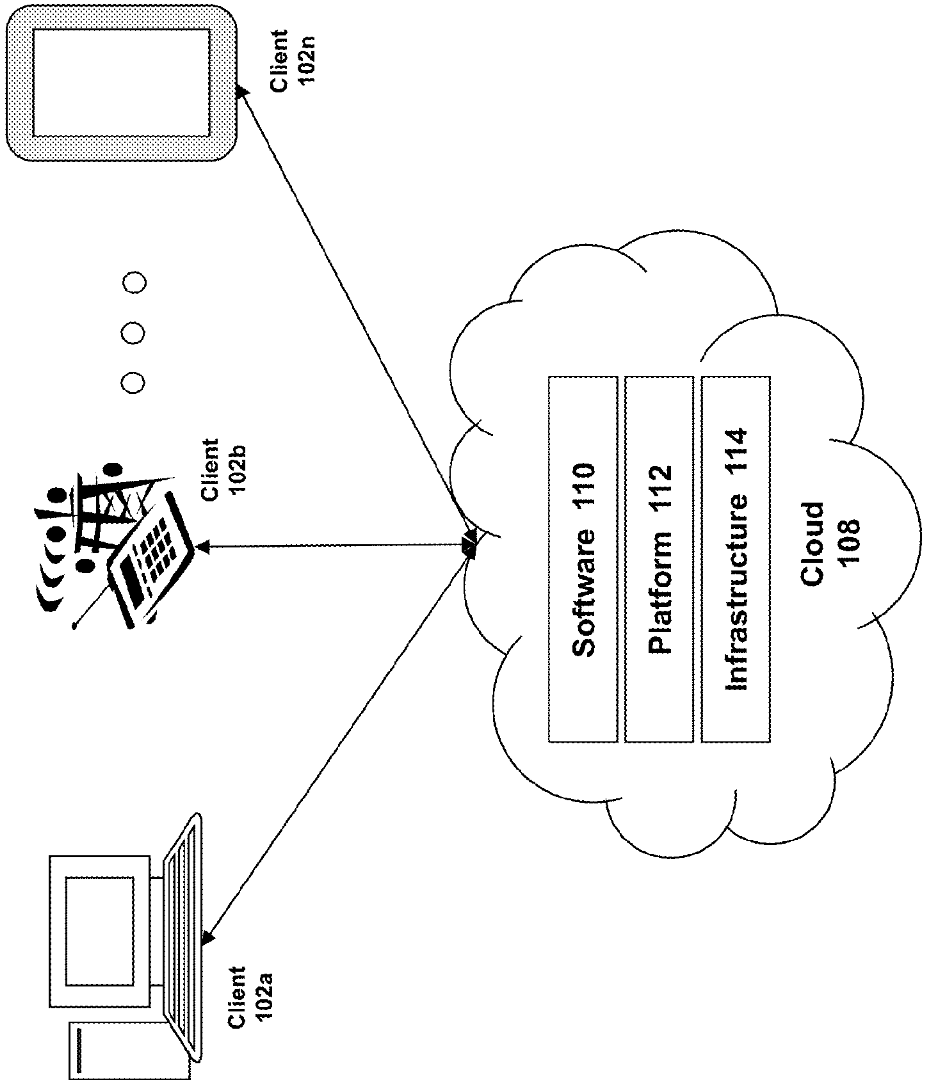
Client
102n
Client
102b
Client
102a
Software 110
Platform 112
Infrastructure 114
Cloud
108

Fig. 1B

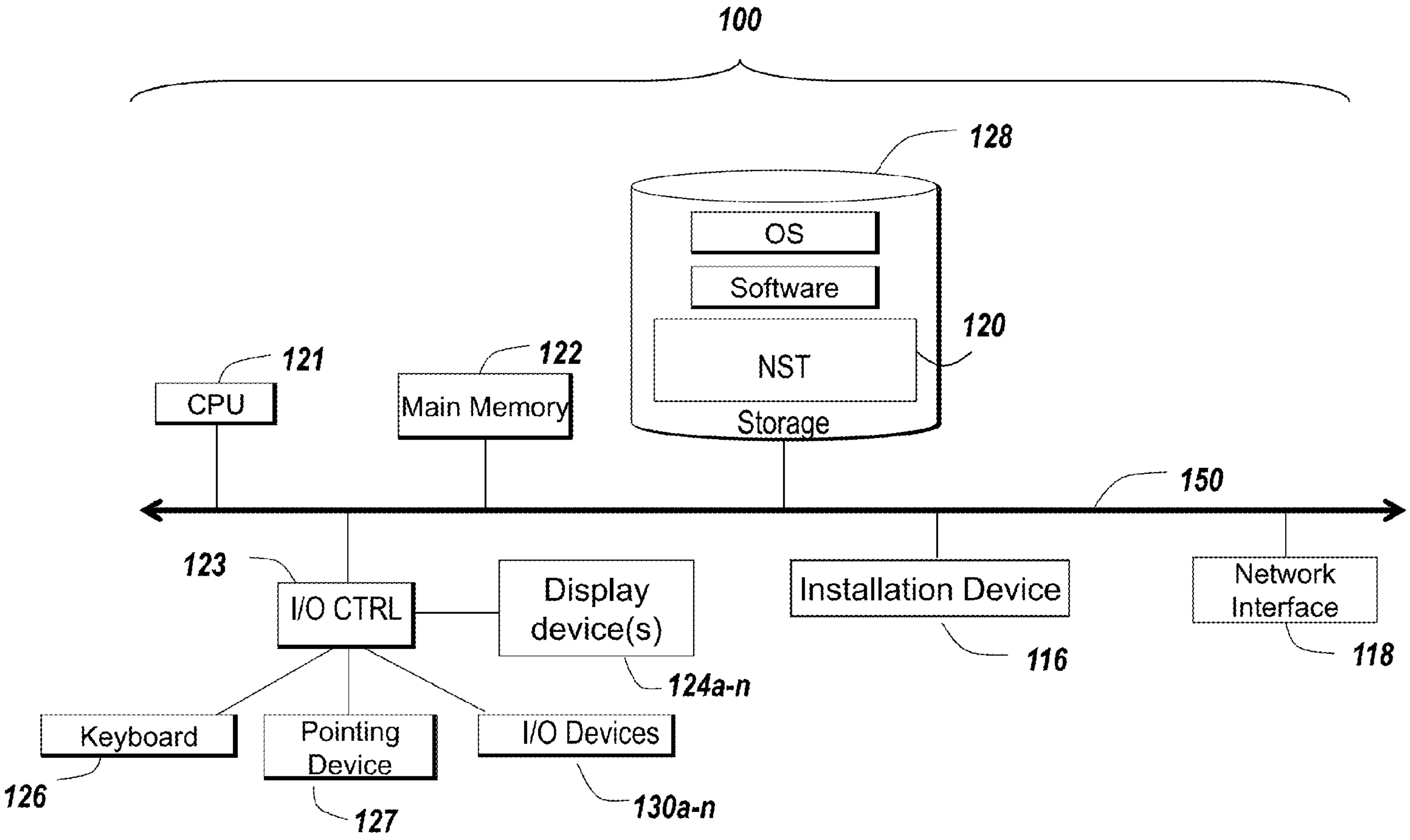
100
128
OS
Software
NST
120
Storage
121
CPU
122
Main Memory
150
123
I/O CTRL
Display
device(s)
124a-n
Installation Device
116
Network
Interface
118
Keyboard
126
Pointing
Device
127
I/O Devices
130a-n

Fig. 1C

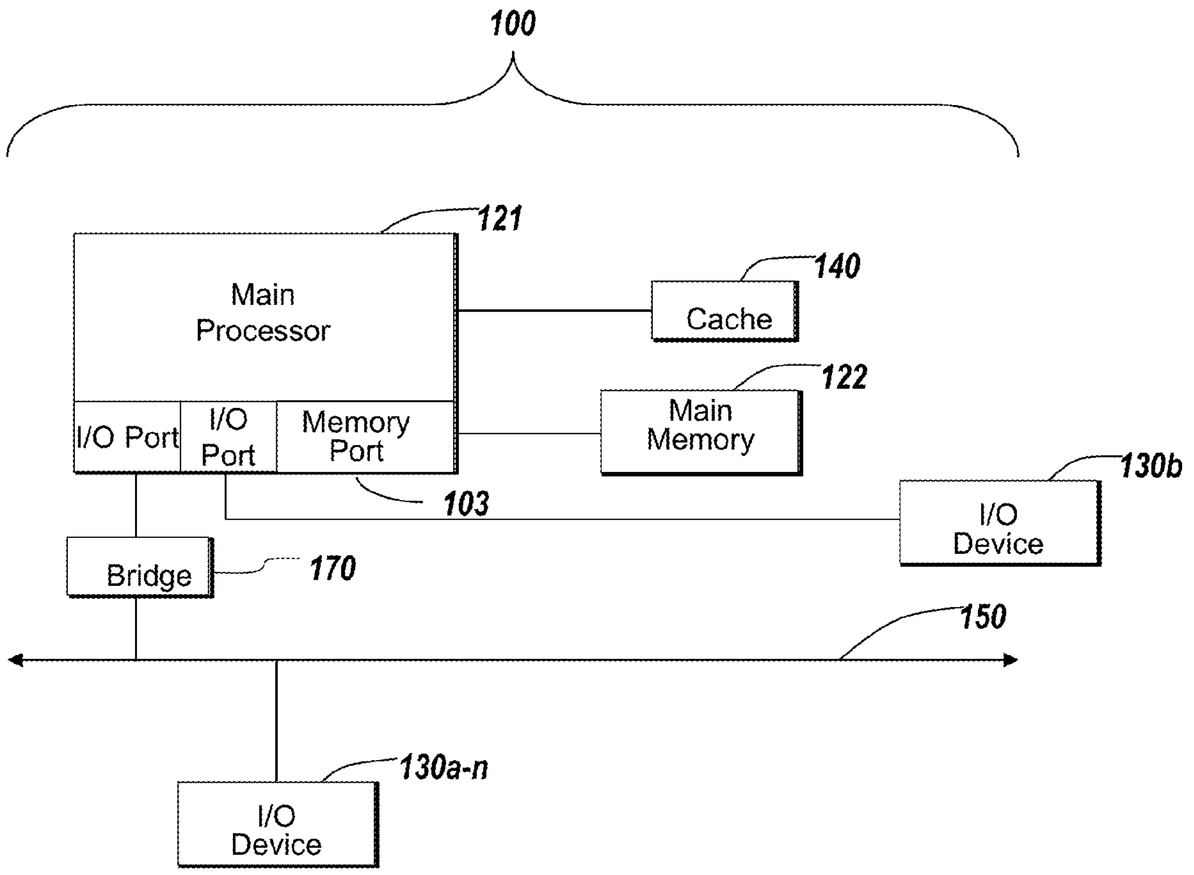
100
121
Main Processor
I/O Port
I/O Port
Memory Port
103
140
Cache
122
Main Memory
130b
I/O Device
Bridge
170
150
130a-n
I/O Device

Fig. 1D

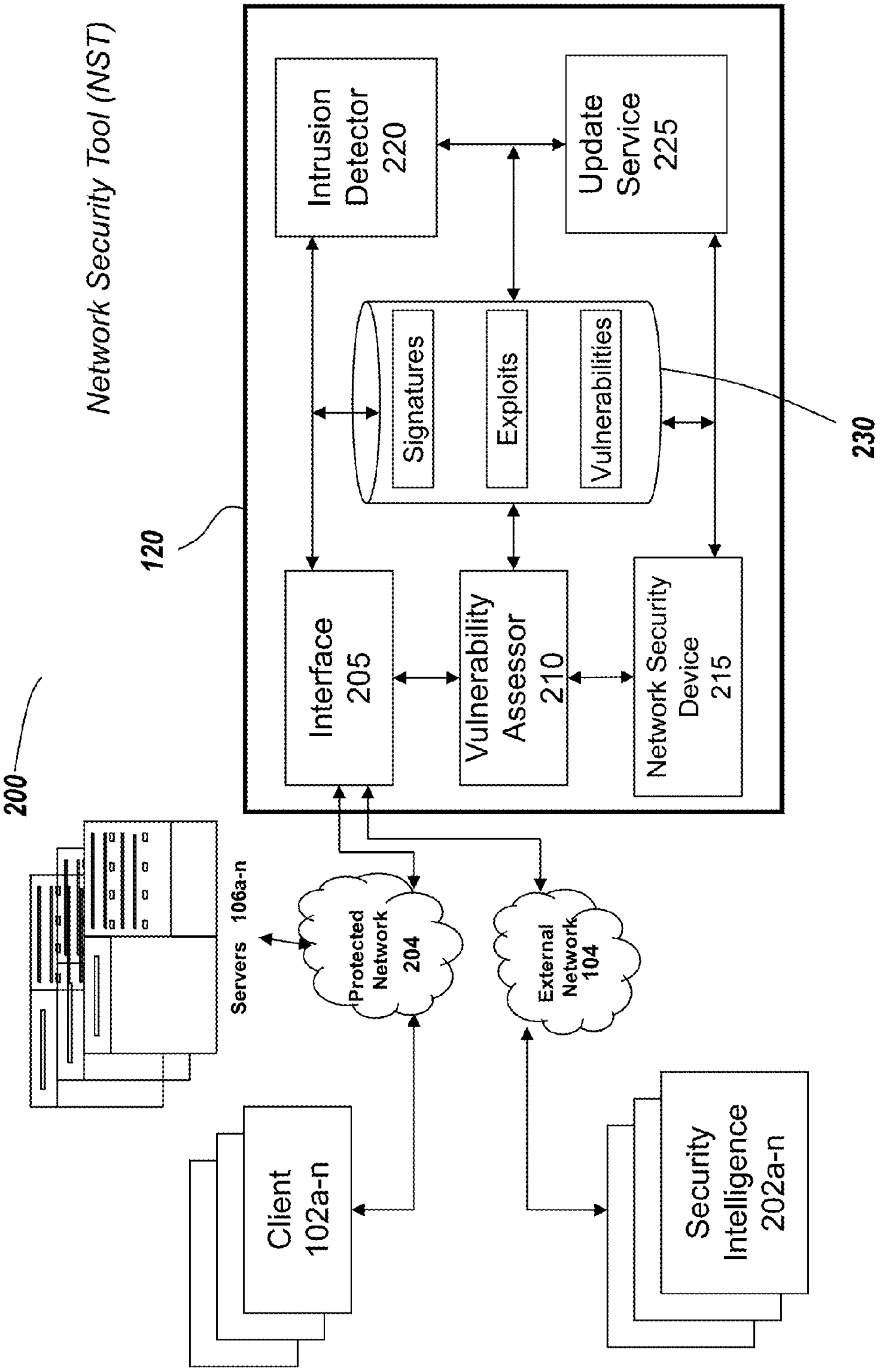
Network Security Tool (NST)
200
120
Intrusion Detector 220
Update Service 225
Signatures
Exploits
Vulnerabilities
230
Interface 205
Vulnerability Assessor 210
Network Security Device 215
Servers 106a-n
Protected Network 204
External Network 104
Client 102a-n
Security Intelligence 202a-n

Fig. 2

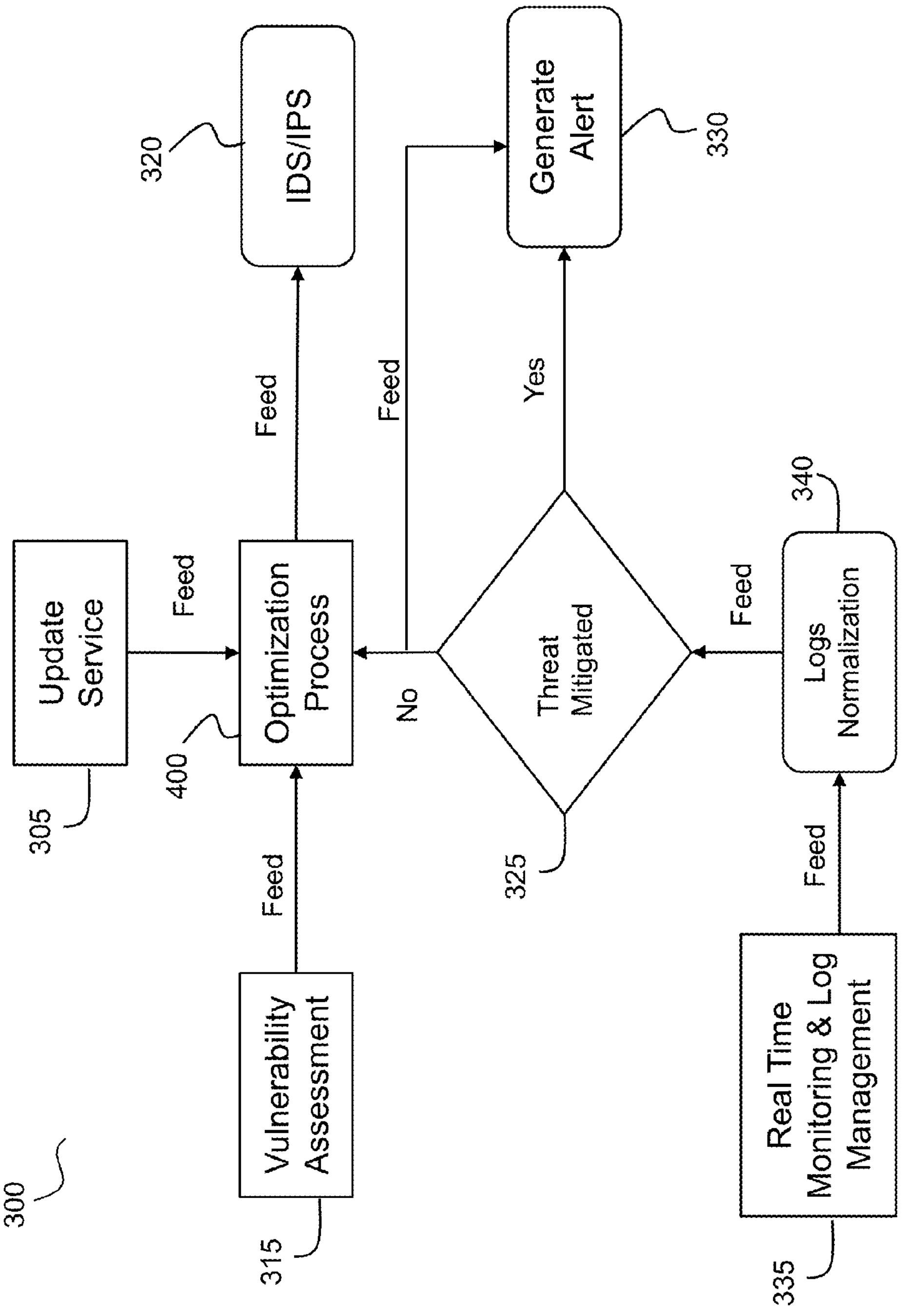
300
Vulnerability Assessment
315
Feed
Optimization Process
400
Update Service
305
Feed
Feed
IDS/IPS
320
No
Feed
Threat Mitigated
325
Yes
Generate Alert
330
Real Time Monitoring & Log Management
335
Feed
Logs Normalization
340
Feed

Fig. 3

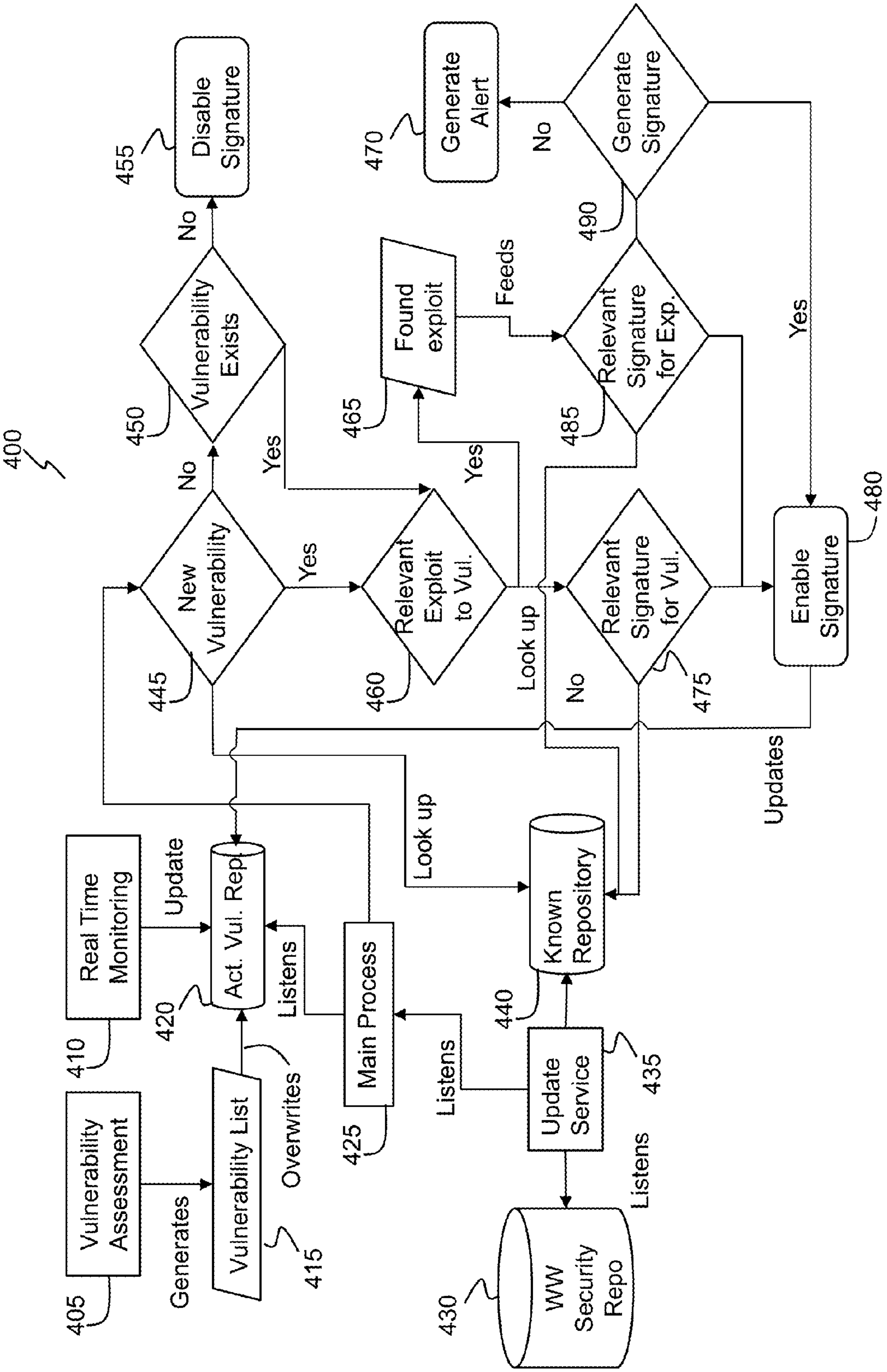
400
405
Vulnerability Assessment
Generates
415
Vulnerability List
Overwrites
410
Real Time Monitoring
Update
420
Act. Vul. Rep.
Listens
425
Main Process
Listens
435
Update Service
Listens
430
WW Security Repo
440
Known Repository
Look up
445
New Vulnerability
No
Yes
450
Vulnerability Exists
No
Yes
455
Disable Signature
460
Relevant Exploit to Vul.
Yes
Look up
465
Found exploit
Feeds
470
Generate Alert
No
475
Relevant Signature for Vul.
No
485
Relevant Signature for Exp.
490
Generate Signature
Yes
480
Enable Signature
Updates

Fig. 4

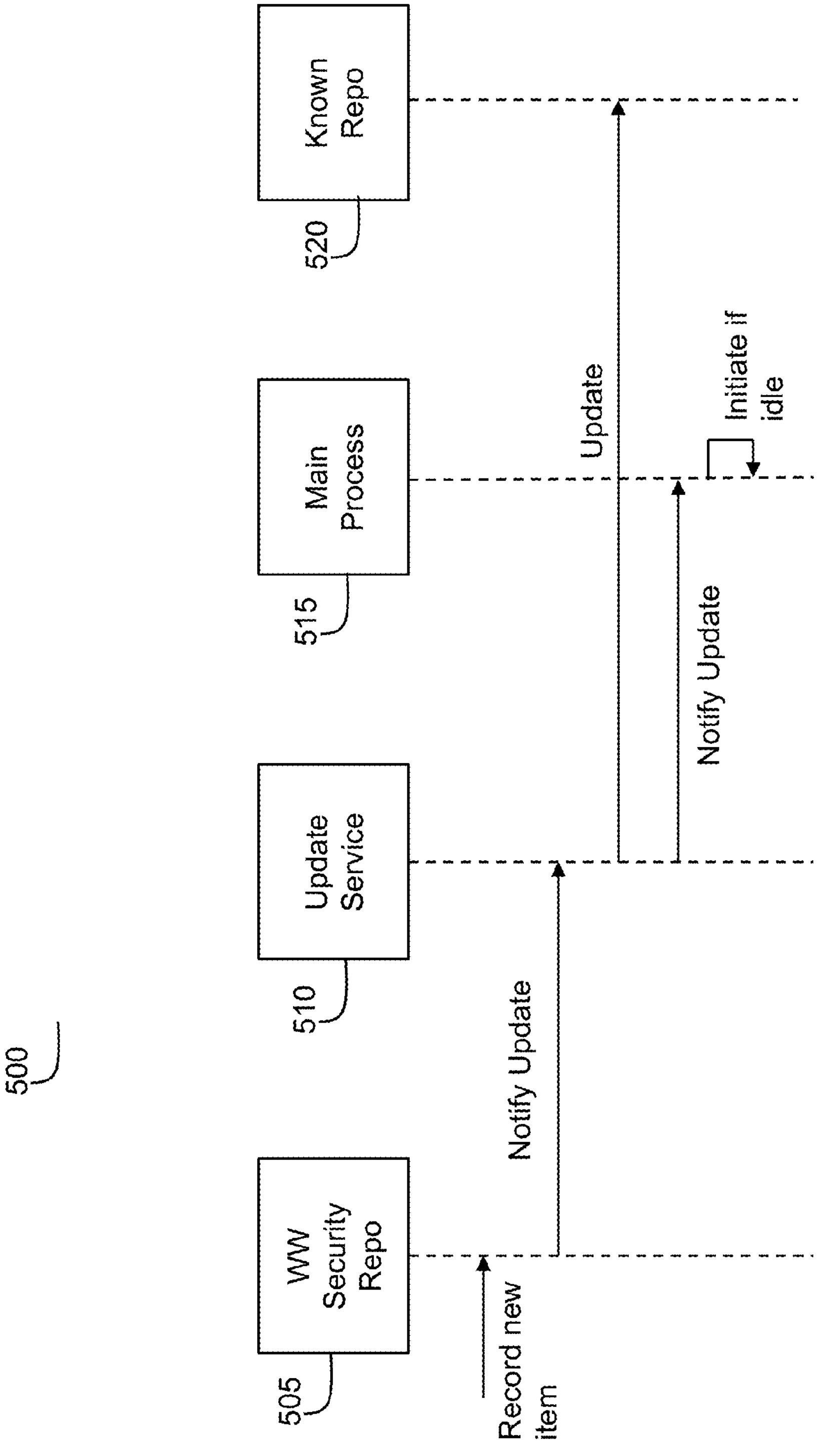
500
WW Security Repo
505
Update Service
510
Main Process
515
Known Repo
520
Record new item
Notify Update
Update
Notify Update
Initiate if idle

Fig. 5

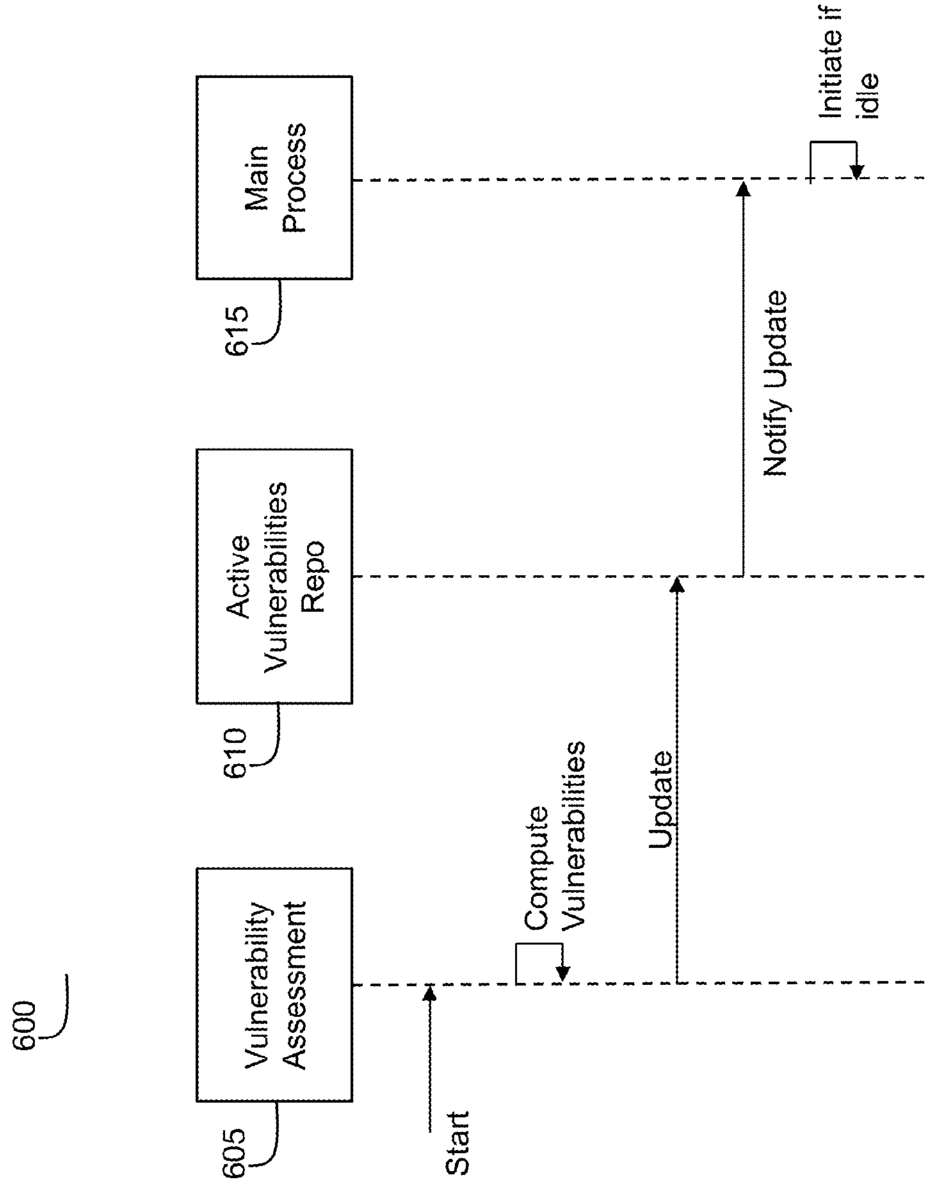
600
605
Vulnerability Assessment
610
Active Vulnerabilities Repo
615
Main Process
Start
Compute Vulnerabilities
Update
Notify Update
Initiate if idle

Fig. 6

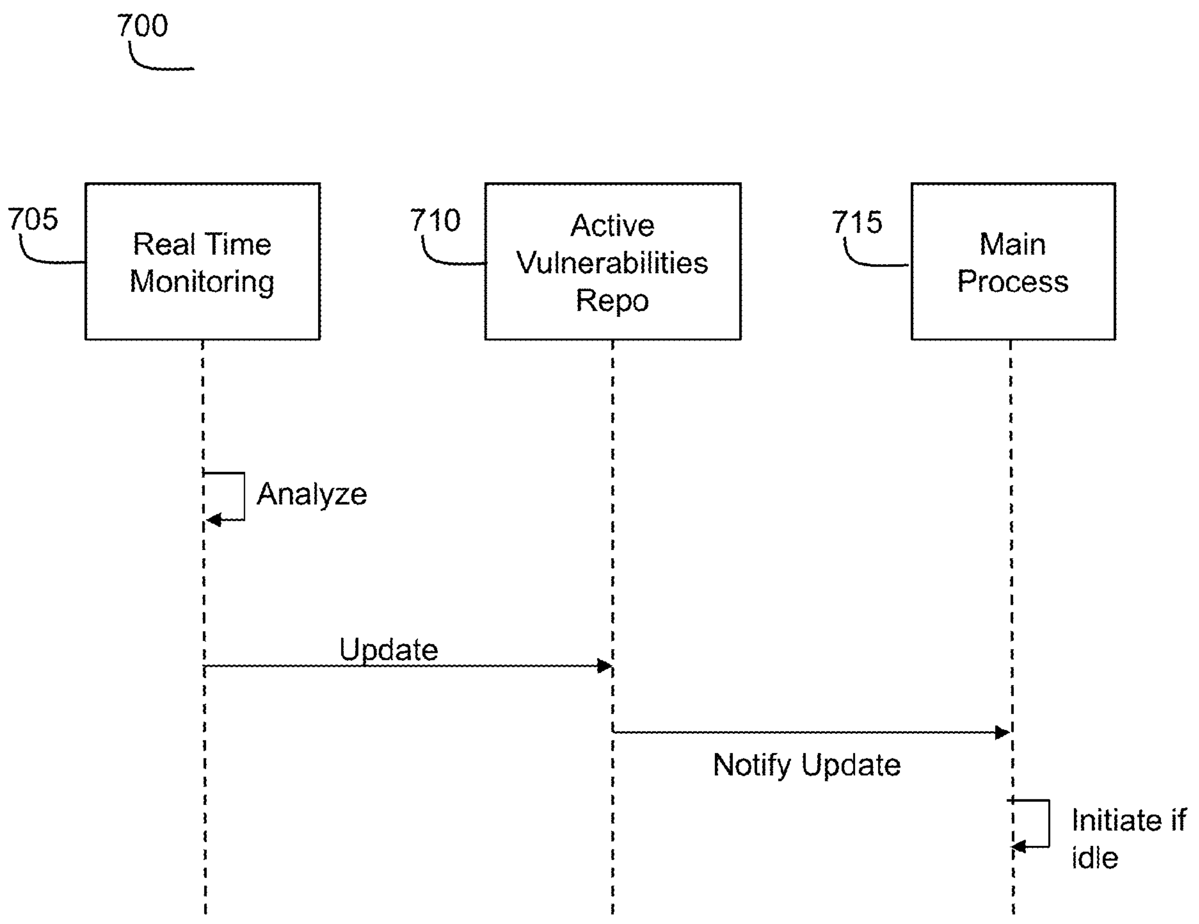
700
705
Real Time Monitoring
710
Active Vulnerabilities Repo
715
Main Process
Analyze
Update
Notify Update
Initiate if idle

Fig. 7

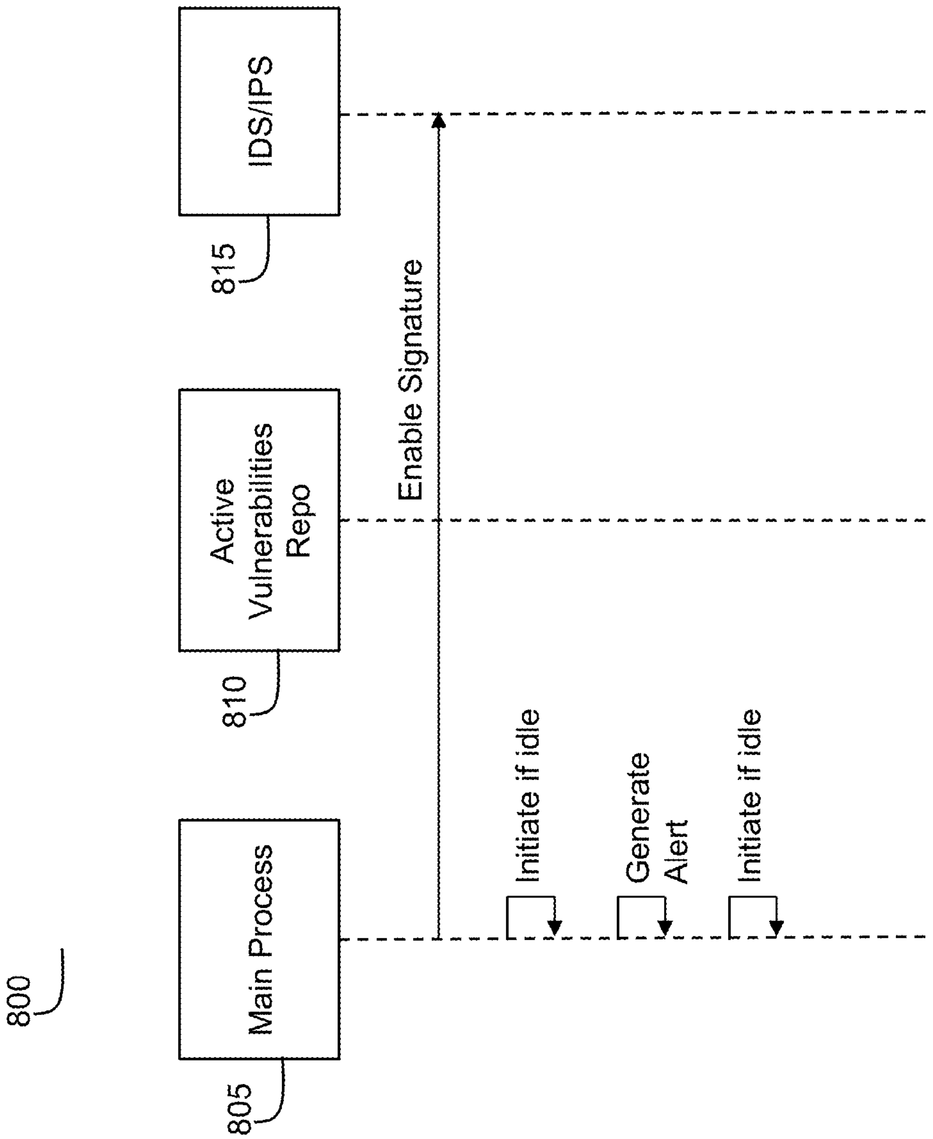
800
Main Process
805
Active Vulnerabilities Repo
810
IDS/IPS
815
Enable Signature
Initiate if idle
Generate Alert
Initiate if idle

Fig. 8

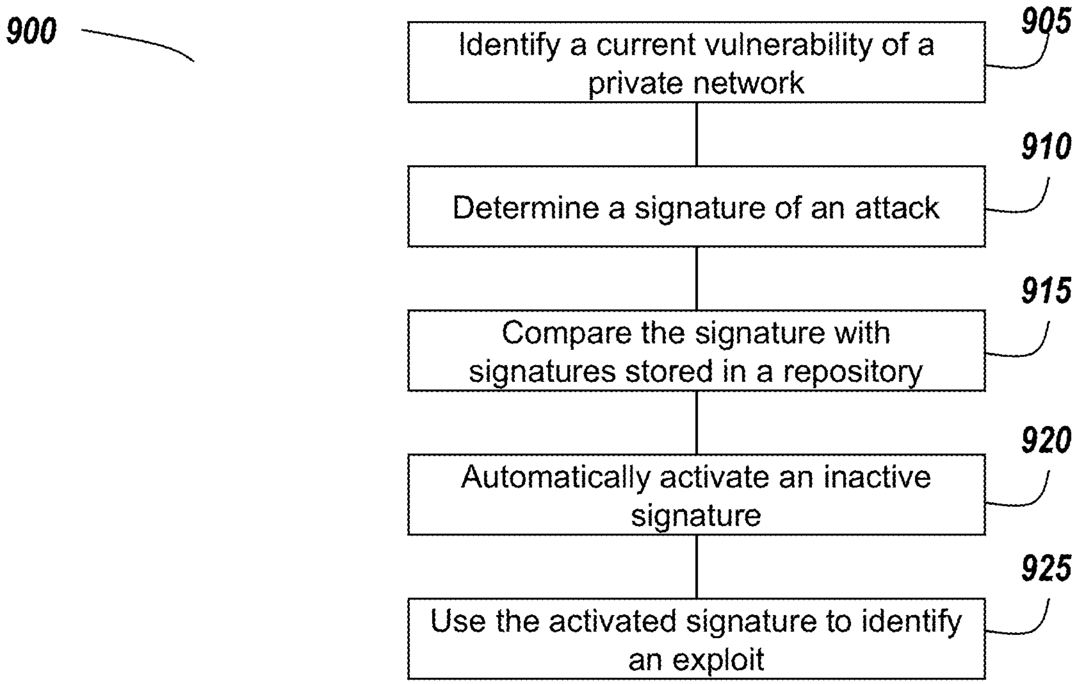
900
Identify a current vulnerability of a private network
905
Determine a signature of an attack
910
Compare the signature with signatures stored in a repository
915
Automatically activate an inactive signature
920
Use the activated signature to identify an exploit
925

Fig. 9

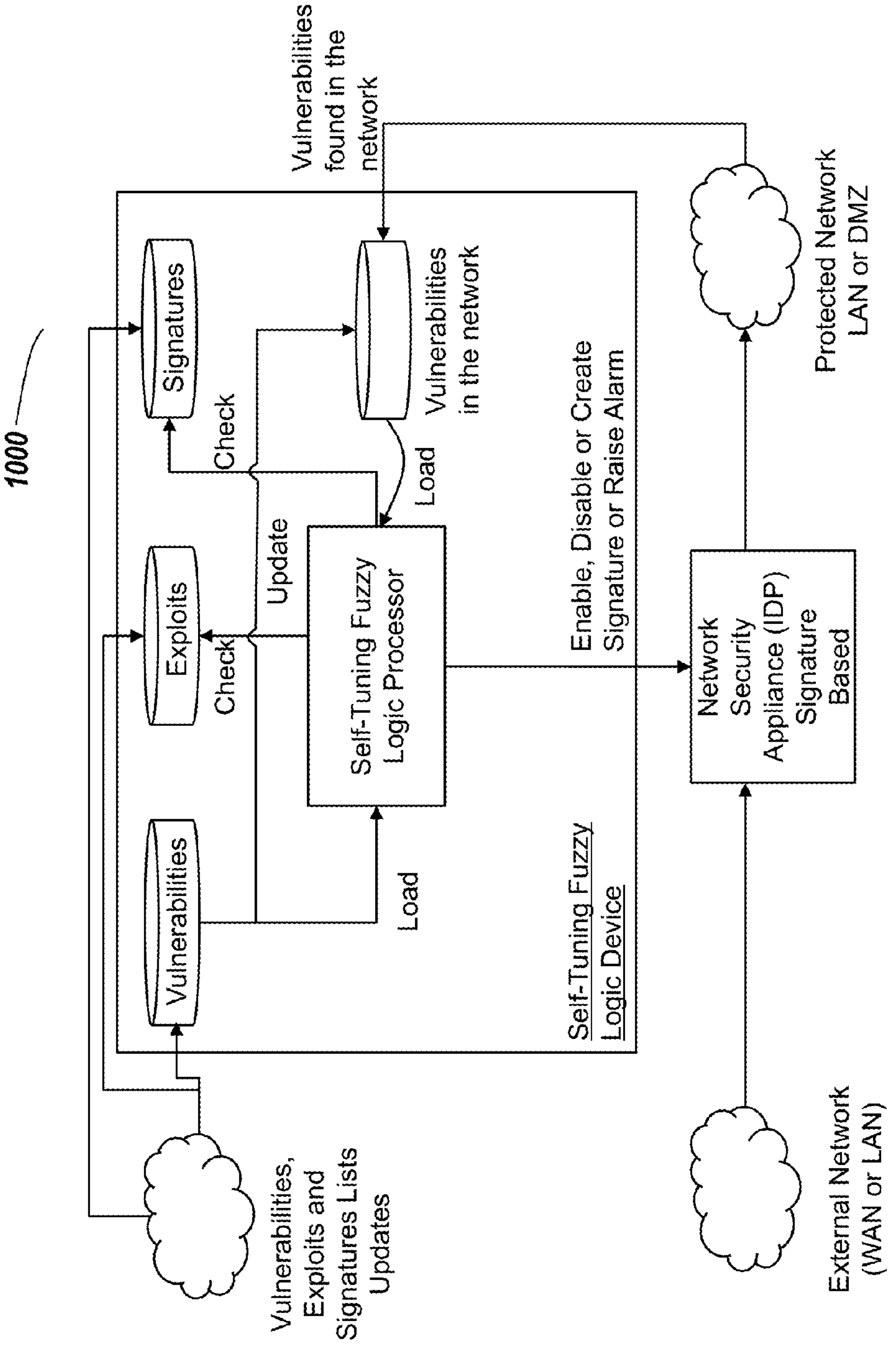
1000
Vulnerabilities, Exploits and Signatures Lists Updates
Vulnerabilities
Exploits
Signatures
Check
Check
Update
Load
Load
Self-Tuning Fuzzy Logic Processor
Vulnerabilities in the network
Vulnerabilities found in the network
Self-Tuning Fuzzy Logic Device
Enable, Disable or Create Signature or Raise Alarm
Network Security Appliance (IDP) Signature Based
External Network (WAN or LAN)
Protected Network LAN or DMZ

Fig. 10

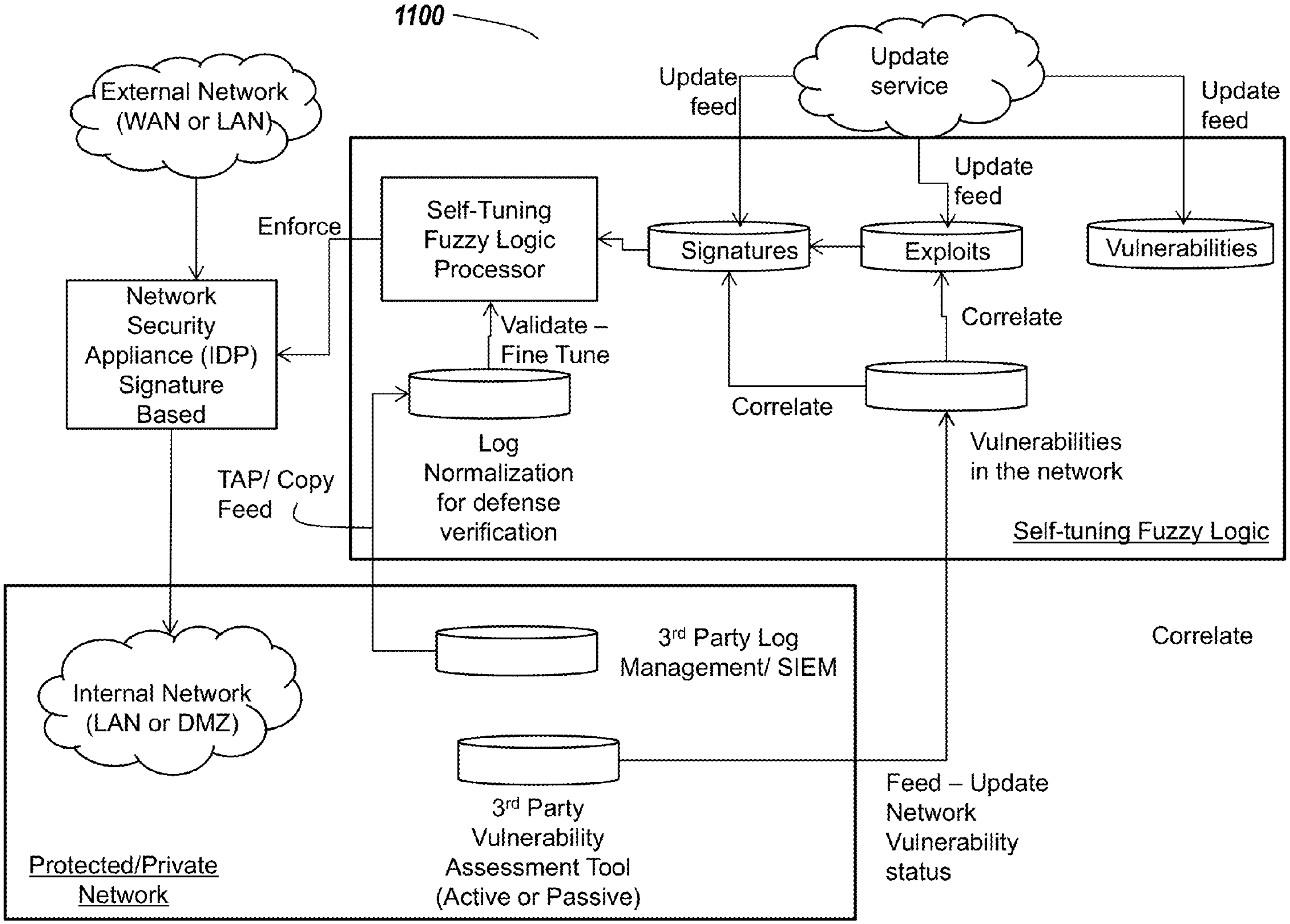
1100
External Network (WAN or LAN)
Update feed
Update service
Update feed
Update feed
Enforce
Self-Tuning Fuzzy Logic Processor
Signatures
Exploits
Vulnerabilities
Network Security Appliance (IDP) Signature Based
Validate – Fine Tune
Correlate
Correlate
TAP/ Copy Feed
Log Normalization for defense verification
Vulnerabilities in the network
Self-tuning Fuzzy Logic
3rd Party Log Management/ SIEM
Correlate
Internal Network (LAN or DMZ)
3rd Party Vulnerability Assessment Tool (Active or Passive)
Feed – Update Network Vulnerability status
Protected/Private Network

Fig. 11

SYSTEMS AND METHODS FOR SELF-TUNING NETWORK INTRUSION DETECTION AND PREVENTION

CROSS-REFERENCE TO RELATED APPLICATIONS

This application claims the benefit of priority under 35 U.S.C. §119 of U.S. Provisional Patent Application No. 61/857,377 filed Jul. 23, 2013, which is incorporated by reference herein in its entirety.

FIELD OF THE DISCLOSURE

This disclosure generally relates to systems and methods for a network security tool. In particular, systems and methods of the present disclosure provide a self-tuning network intrusion detection and prevention system, which is designed to automatically adapt to current threats to the network.

BACKGROUND OF THE DISCLOSURE

Computer networks or systems may have vulnerabilities that can be exploited by an attack or a threat. An exploited vulnerability can adversely affect the operation of the computer network, such as by slowing down the flow of data over the computer network, or preventing access to resources of the computer system.

BRIEF SUMMARY OF THE DISCLOSURE

The present disclosure relates to a self-tuning network intrusion and detection system. In particular, systems and methods of the present disclosure provide a network security tool that protects a private network by monitoring the data packets flowing through the network. The data packets are compared against specific signatures of an intrusion detection and prevention system ("IDS/IPS") defense line of the private network and can thereby be identified as malicious. The tool can activate, deactivate, and generate signatures and alerts. The signatures, which are relevant to the active network vulnerabilities, are activated within the tool, thereby improving the efficiency of the tool and the private network.

Corporations, companies, organizations, and private groups utilize computer networks to communicate, store information, and execute transactions or schedule services. Although computer networks can be created such that they are isolated, most often computer networks are created such that they are linked to the internet and thereby can utilize the internet to send information to more remote locations in the network. For example, a company utilizing a private network which is hosted on the internet can connect various different company locations all together into one network so that information, such as a word document, can be transmitted very quickly between locations which may be separated by fairly large geographical distances. Additionally, networks may be set up such that outside parties can interact with the network over the internet, as is the case in electronic commerce, one of the most common and widespread business practices taking place on the internet. In some situations it is also advantageous to allow external access such that a verified company employee or network member may access information stored on the network even when they are not at a company owned location. By enabling outside interaction with the network these advantages including but not limited to remote access and electronic commerce are enabled.

However, enabling outside access to a network also carries several disadvantages, including attacks from external sources attempting to damage the network or steal information from the network. Stealing information from a network can be particularly damaging to the owners of that network, especially if the information that was stolen is confidential or proprietary information like passwords lists or design plans. The stolen information can sometimes be used to carry out further malicious activities including but not limited to identity theft, further information theft, and asset theft. Such malicious activities can be costly for victims, and as a result, it is important that the chances of a network security breach be minimized.

In response to the threats against networks, networks can include and maintain some form of network security, such as firewalls, intrusion detection systems, intrusion prevention systems, and intrusion detection and prevention systems. Firewalls are in path security measures which are intended to control the flow of information into a network. This is accomplished by examining the incoming data packets and comparing them to a set of rules. Any offending packets, usually assumed to be malicious, are dropped by the firewall, thereby protecting the network that is behind the firewall. Firewalls monitor traffic which is incoming into the network and are capable of dropping data packets which may be malicious. Thus, the firewall may be capable of defending the network from a variety of external threats.

An intrusion detection system detects malicious attacks and then raises an alarm such that an authorized system administrator is notified of the attack and can take the appropriate actions to stymie it. An intrusion prevention system works to identify potential attacks and then automatically takes the appropriate action to disrupt or cease the attack. An intrusion prevention system may or may not notify system administrators when an attack is detected and thwarted by the system. An intrusion detection and prevention system (IDPS) combines these two functionalities, detecting potential attacks and both alerting system administrators and automatically moving to impede the attack. The IDPS may or may not notify system administrators if it is successful in stopping the attack, or may notify a system administrator if it fails to sufficiently stop the attack and other actions may need to be taken.

An IDPS can be implemented via signature detection. In signature detection methodologies, the IDPS monitors data packets which are flowing through the network and compares this information with a pre-determined set of rules which identify known attack patterns. These attack patterns are known as signatures. As the IDPS monitors more signatures, the increased load upon the network and IDPS may increase the amount of time to analyze data packets due to the increase amount of patterns with which the IDPS compares packets. To reduce the load, the IDPS can be tuned to monitor for relevant attack patterns to protect the network are being monitored for by the IDPS. Since not all networks are the same, not all networks have the same vulnerabilities; e.g., a particular exploit for one network may not be viable on another network. Thus, it may be sufficient to maintain monitoring for attack patterns which can actually affect the network being protected.

As it can be challenging and time consuming to tune an IDPS, systems and methods of the present disclosure can facilitate self-tuning a network intrusion detection and prevention system mechanism using a network security tool. The network security tool of the present disclosure can use signature based intrusion detection and prevention and can self-tune by activating and deactivating signatures for which it is monitoring a network. Thus, monitoring for relevant signatures can reduce network load and increasing the efficiency of the network or system. Further, the network security tool can adapt to new threats.

The network security tool can include, use, or gain access to a process, a vulnerability assessment tool, an intrusion detection and prevention system (including a relevant signature list), a monitoring mechanism, and a network connection. The tool (e.g., via a vulnerability assessment tool) can determine or identify vulnerabilities in the network that can be exploited and a possible signature that is indicative of a threat or attack intended to exploit the vulnerability. In some embodiment, the network security tool may include a vulnerability assessment tool. In some embodiments, the network security tool may access or be otherwise communicate with a vulnerability assessment tool (e.g., via a network). The vulnerability assessment tool may detect vulnerabilities in the network, and feed them to the network security tool. The vulnerability assessment tool may feed the detected vulnerabilities in the form of a vulnerabilities list using a common scheme or standard. The vulnerabilities tool may provide a signature list that includes signatures of vulnerabilities or attacks configured to exploit a vulnerability. This signature list can be compared or communicated with a signature list of the IDS/IPS. The signature list of the IDS/IPS may include both active and inactive signatures. Inactive are signatures may or may not have been utilized in the past by the IDS/IPS to perform intrusion detection and prevention, but are not currently taken into consideration in the IDS/IPS monitoring procedures of the network. The IDS/IPS or network security tool may save inactive signatures, in case they might be needed again in the future. The active signatures are the signatures that are actually used in the monitoring of the network by the IDS/IPS to detect or prevent intrusions or attacks configured to exploit a vulnerability. The network connection of the system allows the system (which can be embedded or installed somewhere along the network) to monitor the flow of data through the network, and/or continually probe the network for potential vulnerabilities using the vulnerability assessment tool. For example, the tool may use the output of the vulnerability assessment tool when available, or the tool may perform passive vulnerability scanning on network traffic, data packets, TCP data, or activities logs to determine or identify vulnerabilities of the network. The network connection may provide access to Internet to allow the tool to get up to date with the latest exploits and signatures that are crowd-sourced and specified by the worldwide security community. Thus, the systems and methods of the present disclosure operate on the network to detect threats, identify potential threats, and update the signature list in accordance with new threats or old threats that no longer exist.

At least one aspect is directed to a method of mitigating intrusions via a computer network. The method includes the vulnerability assessment tool identifying a current vulnerability of a private network. The method includes the vulnerability assessment tool determining a signature of an attack configured to exploit the current vulnerability. The method includes a network security device of the network security tool comparing the signature with active and inactive signatures stored in a signature repository. The network security device compares the signatures to identify an inactive signature corresponding to the signature of the attack configured to exploit the current vulnerability. The method includes the network security device automatically activating, responsive to the comparison, the identified inactive signature. The method includes an intrusion detector using the activated signature to identify an exploit based on data packets received via the private network.

In some embodiments, the method includes the vulnerability assessment tool identifying one or more current vulnerabilities of the private network. For example, the vulnerability assessment tool may identify vulnerabilities based on a time interval such as daily, weekly, monthly, hourly, every 12 hours or some other time interval specified by a system administrator or in a configuration file. The method can include the vulnerability assessment tool (e.g., of the network security tool) determining one or more signatures of attacks configured to exploit the one or more current vulnerabilities. The method can include the network security device comparing the one or more signatures with active and inactive signatures stored in a signature repository. The method can include the network security device automatically deactivating, responsive to the comparison, one or more active signature stored in the signature repository that do not correspond to the one or more signatures of the attacks configured to exploit the one or more current vulnerabilities.

In some embodiments, the method can include identifying a second current vulnerability of the private network. The method can include determining a second signature of a second attack configured to exploit the second current vulnerability. The method can include comparing the second signature with the active and inactive signatures stored in the signature repository. The method can include determining, based on the comparison, that the second signature corresponds to an active signature stored in the signature repository. The method can include using, by the intrusion detector, the active signature corresponding to the second signature to identify a second exploit based on data packets received via the private network.

In some embodiments, the method includes identifying a plurality of current vulnerabilities of the private network. The method can include identifying a plurality of signatures corresponding to the plurality of current vulnerabilities. The method can include comparing the plurality of signatures with the active and inactive signatures stored in the signature repository. The method can include automatically activating, responsive to the comparison, inactive signatures stored in the signature repository that correspond to the plurality of signatures. The method can include automatically deactivating, responsive to the comparison, active signatures stored in the signature repository that do not correspond to the plurality of signatures.

In some embodiments, the method can include receiving an indication that the current vulnerability is resolved. The method can include automatically deactivating, responsive to the indication, the signature corresponding to the current vulnerability. In some embodiments, the method can include using a fuzzy logic algorithm to determine the signature of the attack configured to exploit the current vulnerability.

In some embodiments, the method can include identifying a second current vulnerability of the private network. The method can include determining a second signature of a second attack configured to exploit the second current vulnerability. The method can include comparing the second signature with the active and inactive signatures stored in the signature repository. The method can include determining, based on the comparison, that the second signature does not correspond to active or inactive signatures stored in the signature repository. The method can include automatically generating, based on the comparison, a new signature based on the second signature. The method can include activating and storing the new signature in the signature repository for use by the intrusion detector.

In some embodiments, the signature comprises an attack pattern. In some embodiments, the method includes receiving a plurality of logs of network activity associated with computing devices of the protected network. In some embodiments, the method includes determining, based on the plurality of logs, a pattern indicative of a signature of an attack.

In some embodiments, the method includes monitoring, by the intrusion detector, the data packets of the private network to identify the exploit based on the active signature corresponding to the second signature. The method can include responsive to identifying the second exploit, generating an alert. The method can include providing the alert to an administrator device of the private network. In some embodiments, the method can include obtaining, via a public network, updates on current vulnerabilities established by a plurality of users of the public network.

In some embodiments, the method includes identifying, by the vulnerability assessment tool, a second active signature stored in the signature repository. The method can include obtaining, by the network security device, a plurality of signatures corresponding to one or more active vulnerabilities of the private network. The method can include automatically deactivating, by the network security device, the second signature responsive to the second signature being absent from the plurality of signatures corresponding to the one or more active vulnerabilities of the private network.

At least one aspect is directed to a system for mitigating intrusions via a computer network. The system includes a vulnerability assessment tool. The vulnerability assessment tool is configured to identify a current vulnerability of a private network and determine a signature of an attack configured to exploit the current vulnerability. The system includes a network security device. The network security device is configured to compare the signature with active and inactive signatures stored in a signature repository. The network security device compares the signature to identify an inactive signature corresponding to the signature of the attack configured to exploit the current vulnerability. The network security device is further configured to automatically activate, responsive to the comparison, the identified inactive signature. The network security device is further configured to deactivate, responsive to the comparison, an active signature stored in the signature repository that does not correspond to the signature of the attack configured to exploit the current vulnerability. The system includes an intrusion detector configured to use the activated signature to identify an exploit based on data packets received via the private network.

In some embodiments, the vulnerability assessment tool is further configured to identify a second current vulnerability of the private network and determine a second signature of a second attack configured to exploit the second current vulnerability. In some embodiments, the network security device is further configured to compare the second signature with the active and inactive signatures stored in the signature repository. The network security device can be further configured to determine, based on the comparison, that the second signature corresponds to an active signature stored in the signature repository. The intrusion detector can be further configured to use the active signature corresponding to the second signature to identify a second exploit based on data packets received via the private network.

In some embodiments, the vulnerability assessment tool is further configured to identify a plurality of current vulnerabilities of the private network and identify a plurality of signatures corresponding to the plurality of current vulnerabilities. The network security device can be further configured to compare the plurality of signatures with the active and inactive signatures stored in the signature repository. The network security device can be further configured to automatically activate, responsive to the comparison, inactive signatures stored in the signature repository that correspond to the plurality of signatures. The network security device can be further configured to automatically deactivate, responsive to the comparison, active signatures stored in the signature repository that do not correspond to the plurality of signatures.

In some embodiments, the system can be further configured to receive an indication that the current vulnerability is resolved. The system can be further configured to automatically deactivate, responsive to the indication, the signature corresponding to the current vulnerability.

In some embodiments, the vulnerability assessment tool is further configured to use a fuzzy logic algorithm to determine the signature of the attack configured to exploit the current vulnerability.

In some embodiments, the vulnerability assessment tool is further configured to identify a second current vulnerability of the private network and determine a second signature of a second attack configured to exploit the second current vulnerability. The network security device can be further configured to compare the second signature with the active and inactive signatures stored in the signature repository. The network security device can be further configured to determine, based on the comparison, that the second signature does not correspond to active or inactive signatures stored in the signature repository. The network security device can be further configured to automatically generate, based on the comparison, a new signature based on the second signature. The network security device can be further configured to activate and store the new signature in the signature repository for use by the intrusion detector.

In some embodiments, the signature comprises an attack pattern. In some embodiments, the network security tool includes a passive vulnerability assessor configured to passively monitor network traffic or activities logs to identify a vulnerability, an exploit of the vulnerability, or a signature of an attack configured to exploit the vulnerability. In some embodiments, the passive vulnerability assessor is further configured to receive a plurality of logs of network activity associated with computing devices of the protected network. In some embodiments, the system is further configured to determine, based on the plurality of logs, a pattern indicative of a signature of an attack.

In some embodiments, the intrusion detector is further configured to monitor the data packets of the private network to identify the exploit based on the active signature corresponding to the second signature. The intrusion detector can be further configured to responsive to identifying the second exploit, generate an alert. The intrusion detector can be further configured to provide the alert to an administrator device of the private network.

At least one aspect is directed to a system to collect, analyze, store and process vulnerability information, exploits and exploit code information and intrusion detection signature information utilized by a user. The system can include a plurality of sources providing the vulnerability information. The sources can provide the exploits and exploit code information associated with the vulnerability information. The sources can also provide the intrusion detection signatures information. The system can include a vulnerability database updated at least daily. The vulnerability database can be in communication with the system. The system can include a plurality of modules to collect, analyze, store and process the vulnerability information. The exploits and exploit code information and the intrusion detection signature information can use one or more topological vulnerability analysis techniques.

In some embodiments, the plurality of sources include a common vulnerabilities and exposures list. In some embodiments, the sources include a dynamic list maintained by one or more vendors. In some embodiments, the sources include one or more response centers, such as a Computer Emergency Response Centers (CERT). In some embodiments, the sources include one or more independent security researchers.

In some embodiments, the system includes a vulnerabilities database and a signature database. The vulnerabilities database and the signature database are in communication with the system. In some embodiments, the system includes an exploits database that is in communication with the system. In some embodiments, the system includes an intrusion detection signatures database that is in communication with the system.

In some embodiments, the exploits and exploits code information is obtained from one or more websites, from one or more security tools, or from one or more mailing lists. In some embodiments, the vulnerability information is obtained from one or more vulnerability assessment tools, one or more vendor websites, one or more associated mailing lists, or one or more open source research communities. In some embodiments, the information related to the intrusion detection and prevention signature is obtained from one or more intrusion detection and prevention systems, one or more intrusion detection and prevention vendor websites, one or more associated mailing lists, or one or more open source research communities.

In some embodiments, the system can include one or more modules or components including, e.g., a vulnerability collection module, a vulnerability storage module, an intrusion detection signature collection module, an intrusion detection signature storage module, an exploits collection module, and an exploits storage module.

In some embodiments, the system normalizes the vulnerability information. In some embodiments, the system presents the information to the user as output. In some embodiments, the system correlates the vulnerability information with the exploits and exploit code information and the intrusion detection signatures information. The system can correlate this information using topological vulnerability information by matching the exploits and exploit code information related to the vulnerability information and the intrusion detection signatures information related to the vulnerability information and the exploit and exploit code information.

In some embodiments, the system calculates a significance of the collected and stored vulnerability information, utilizing one or more common vulnerability scoring systems. In some embodiments, the system presents the significance of the collected and stored vulnerability information to the user based on the significance of the stored vulnerability information. In some embodiments, the system presents the intrusion detection signatures needed to mitigate the significance of the collected and stored vulnerability information to the user.

BRIEF DESCRIPTION OF THE DRAWINGS

The foregoing and other objects, aspects, features, and advantages of the disclosure will become more apparent and

better understood by referring to the following description taken in conjunction with the accompanying drawings, in which:

FIG. **1**A is a block diagram depicting an embodiment of a network environment comprising client device in communication with server device;

FIG. **1**B is a block diagram depicting a cloud computing environment comprising client device in communication with cloud service providers;

FIGS. **1**C and **1**D are block diagrams depicting embodiments of computing devices useful in connection with the methods and systems described herein.

FIG. **2** is an illustrative embodiment of a system comprising a network security tool.

FIG. **3** is an illustrative overview of a flow diagram for a network security tool, in accordance with an embodiment.

FIGS. **4-8** are illustrative flow diagrams of self-tuning processes of the network security tool, in accordance with embodiments.

FIG. **9** is an illustrative embodiment of a method of mitigating intrusions using a network security tool.

FIGS. **10** and **11** are illustrative implementations of a network security tool, in accordance with embodiments.

DETAILED DESCRIPTION

For purposes of reading the description of the various embodiments below, the following descriptions of the sections of the specification and their respective contents may be helpful:

Section A describes a network environment and computing environment which may be useful for practicing embodiments described herein.

Section B describes embodiments of systems and methods for a network security tool.

A. Computing and Network Environment

Prior to discussing specific embodiments of the present solution, it may be helpful to describe aspects of the operating environment as well as associated system components (e.g., hardware elements) in connection with the methods and systems described herein. Referring to FIG. **1**A, an embodiment of a network environment is depicted. In brief overview, the network environment includes one or more clients **102*a*-102*n*** (also generally referred to as local machine(s) **102**, client(s) **102**, client node(s) **102**, client machine(s) **102**, client computer(s) **102**, client device(s) **102**, endpoint(s) **102**, or endpoint node(s) **102**) in communication with one or more servers **106*a*-106*n*** (also generally referred to as server(s) **106**, node **106**, or remote machine(s) **106**) via one or more networks **104**. In some embodiments, a client **102** has the capacity to function as both a client node seeking access to resources provided by a server and as a server providing access to hosted resources for other clients **102*a*-102*n***.

Although FIG. **1**A shows a network **104** between the clients **102** and the servers **106**, the clients **102** and the servers **106** may be on the same network **104**. In some embodiments, there are multiple networks **104** between the clients **102** and the servers **106**. In one of these embodiments, a network **104'** (not shown) may be a private network and a network **104** may be a public network. In another of these embodiments, a network **104** may be a private network and a network **104'** a public network. In still another of these embodiments, networks **104** and **104'** may both be private networks.

The network **104** may be connected via wired or wireless links. Wired links may include Digital Subscriber Line (DSL), coaxial cable lines, or optical fiber lines. The wireless links may include BLUETOOTH, Wi-Fi, Worldwide Interoperability for Microwave Access (WiMAX), an infrared channel or satellite band. The wireless links may also include any cellular network standards used to communicate among mobile devices, including standards that qualify as 1G, 2G, 3G, or 4G. The network standards may qualify as one or more generation of mobile telecommunication standards by fulfilling a specification or standards such as the specifications maintained by International Telecommunication Union. The 3G standards, for example, may correspond to the International Mobile Telecommunications-2000 (IMT-2000) specification, and the 4G standards may correspond to the International Mobile Telecommunications Advanced (IMT-Advanced) specification. Examples of cellular network standards include AMPS, GSM, GPRS, UMTS, LTE, LTE Advanced, Mobile WiMAX, and WiMAX-Advanced. Cellular network standards may use various channel access methods e.g. FDMA, TDMA, CDMA, or SDMA. In some embodiments, different types of data may be transmitted via different links and standards. In other embodiments, the same types of data may be transmitted via different links and standards.

The network **104** may be any type and/or form of network. The geographical scope of the network **104** may vary widely and the network **104** can be a body area network (BAN), a personal area network (PAN), a local-area network (LAN), e.g. Intranet, a metropolitan area network (MAN), a wide area network (WAN), or the Internet. The topology of the network **104** may be of any form and may include, e.g., any of the following: point-to-point, bus, star, ring, mesh, or tree. The network **104** may be an overlay network which is virtual and sits on top of one or more layers of other networks **104'**. The network **104** may be of any such network topology as known to those ordinarily skilled in the art capable of supporting the operations described herein. The network **104** may utilize different techniques and layers or stacks of protocols, including, e.g., the Ethernet protocol, the internet protocol suite (TCP/IP), the ATM (Asynchronous Transfer Mode) technique, the SONET (Synchronous Optical Networking) protocol, or the SDH (Synchronous Digital Hierarchy) protocol. The TCP/IP internet protocol suite may include application layer, transport layer, internet layer (including, e.g., IPv6), or the link layer. The network **104** may be a type of a broadcast network, a telecommunications network, a data communication network, or a computer network.

In some embodiments, the system may include multiple, logically-grouped servers **106**. In one of these embodiments, the logical group of servers may be referred to as a server farm **38** or a machine farm **38**. In another of these embodiments, the servers **106** may be geographically dispersed. In other embodiments, a machine farm **38** may be administered as a single entity. In still other embodiments, the machine farm **38** includes a plurality of machine farms **38**. The servers **106** within each machine farm **38** can be heterogeneous—one or more of the servers **106** or machines **106** can operate according to one type of operating system platform (e.g., WINDOWS NT, manufactured by Microsoft Corp. of Redmond, Wash.), while one or more of the other servers **106** can operate on according to another type of operating system platform (e.g., Unix, Linux, or Mac OS X).

In one embodiment, servers **106** in the machine farm **38** may be stored in high-density rack systems, along with associated storage systems, and located in an enterprise data center. In this embodiment, consolidating the servers **106** in this way may improve system manageability, data security, the physical security of the system, and system performance by locating servers **106** and high performance storage systems on localized high performance networks. Centralizing the servers **106** and storage systems and coupling them with advanced system management tools allows more efficient use of server resources.

The servers **106** of each machine farm **38** do not need to be physically proximate to another server **106** in the same machine farm **38**. Thus, the group of servers **106** logically grouped as a machine farm **38** may be interconnected using a wide-area network (WAN) connection or a metropolitan-area network (MAN) connection. For example, a machine farm **38** may include servers **106** physically located in different continents or different regions of a continent, country, state, city, campus, or room. Data transmission speeds between servers **106** in the machine farm **38** can be increased if the servers **106** are connected using a local-area network (LAN) connection or some form of direct connection. Additionally, a heterogeneous machine farm **38** may include one or more servers **106** operating according to a type of operating system, while one or more other servers **106** execute one or more types of hypervisors rather than operating systems. In these embodiments, hypervisors may be used to emulate virtual hardware, partition physical hardware, virtualize physical hardware, and execute virtual machines that provide access to computing environments, allowing multiple operating systems to run concurrently on a host computer. Native hypervisors may run directly on the host computer. Hypervisors may include VMware ESX/ESXi, manufactured by VMWare, Inc., of Palo Alto, Calif.; the Xen hypervisor, an open source product whose development is overseen by Citrix Systems, Inc.; the HYPER-V hypervisors provided by Microsoft or others. Hosted hypervisors may run within an operating system on a second software level. Examples of hosted hypervisors may include VMware Workstation and VIRTUALBOX.

Management of the machine farm **38** may be de-centralized. For example, one or more servers **106** may comprise components, subsystems and modules to support one or more management services for the machine farm **38**. In one of these embodiments, one or more servers **106** provide functionality for management of dynamic data, including techniques for handling failover, data replication, and increasing the robustness of the machine farm **38**. Each server **106** may communicate with a persistent store and, in some embodiments, with a dynamic store.

Server **106** may be a file server, application server, web server, proxy server, appliance, network appliance, gateway, gateway server, virtualization server, deployment server, SSL VPN server, or firewall. In one embodiment, the server **106** may be referred to as a remote machine or a node. In another embodiment, a plurality of nodes **290** may be in the path between any two communicating servers.

Referring to FIG. **1**B, a cloud computing environment is depicted. A cloud computing environment may provide client **102** with one or more resources provided by a network environment. The cloud computing environment may include one or more clients **102***a*-**102***n*, in communication with the cloud **108** over one or more networks **104**. Clients **102** may include, e.g., thick clients, thin clients, and zero clients. A thick client may provide at least some functionality even when disconnected from the cloud **108** or servers **106**. A thin client or a zero client may depend on the connection to the cloud **108** or server **106** to provide functionality. A zero client may depend on the cloud **108** or other networks **104** or servers **106** to retrieve operating system data for the client device. The cloud **108** may include back end platforms, e.g., servers **106**, storage, server farms or data centers.

The cloud **108** may be public, private, or hybrid. Public clouds may include public servers **106** that are maintained by third parties to the clients **102** or the owners of the clients. The servers **106** may be located off-site in remote geographical locations as disclosed above or otherwise. Public clouds may be connected to the servers **106** over a public network. Private clouds may include private servers **106** that are physically maintained by clients **102** or owners of clients. Private clouds may be connected to the servers **106** over a private network **104**. Hybrid clouds **108** may include both the private and public networks **104** and servers **106**.

The cloud **108** may also include a cloud based delivery, e.g. Software as a Service (SaaS) **110**, Platform as a Service (PaaS) **112**, and Infrastructure as a Service (IaaS) **114**. IaaS may refer to a user renting the use of infrastructure resources that are needed during a specified time period. IaaS providers may offer storage, networking, servers or virtualization resources from large pools, allowing the users to quickly scale up by accessing more resources as needed. Examples of IaaS can include infrastructure and services (e.g., EG-32) provided by OVH HOSTING of Montreal, Quebec, Canada, AMAZON WEB SERVICES provided by Amazon.com, Inc., of Seattle, Wash., RACKSPACE CLOUD provided by Rackspace US, Inc., of San Antonio, Tex., Google Compute Engine provided by Google Inc. of Mountain View, Calif., or RIGHTSCALE provided by RightScale, Inc., of Santa Barbara, Calif. PaaS providers may offer functionality provided by IaaS, including, e.g., storage, networking, servers or virtualization, as well as additional resources such as, e.g., the operating system, middleware, or runtime resources. Examples of PaaS include WINDOWS AZURE provided by Microsoft Corporation of Redmond, Wash., Google App Engine provided by Google Inc., and HEROKU provided by Heroku, Inc. of San Francisco, Calif. SaaS providers may offer the resources that PaaS provides, including storage, networking, servers, virtualization, operating system, middleware, or runtime resources. In some embodiments, SaaS providers may offer additional resources including, e.g., data and application resources. Examples of SaaS include GOOGLE APPS provided by Google Inc., SALESFORCE provided by Salesforce.com Inc. of San Francisco, Calif., or OFFICE 365 provided by Microsoft Corporation. Examples of SaaS may also include data storage providers, e.g. DROPBOX provided by Dropbox, Inc. of San Francisco, Calif., Microsoft SKYDRIVE provided by Microsoft Corporation, Google Drive provided by Google Inc., or Apple ICLOUD provided by Apple Inc. of Cupertino, Calif.

Clients **102** may access IaaS resources with one or more IaaS standards, including, e.g., Amazon Elastic Compute Cloud (EC2), Open Cloud Computing Interface (OCCI), Cloud Infrastructure Management Interface (CIMI), or OpenStack standards. Some IaaS standards may allow clients access to resources over HTTP, and may use Representational State Transfer (REST) protocol or Simple Object Access Protocol (SOAP). Clients **102** may access PaaS resources with different PaaS interfaces. Some PaaS interfaces use HTTP packages, standard Java APIs, JavaMail API, Java Data Objects (JDO), Java Persistence API (JPA), Python APIs, web integration APIs for different programming languages including, e.g., Rack for Ruby, WSGI for Python, or PSGI for Perl, or other APIs that may be built on REST, HTTP, XML, or other protocols. Clients **102** may access SaaS resources through the use of web-based user interfaces, provided by a web browser (e.g. GOOGLE CHROME, Microsoft INTERNET EXPLORER, or Mozilla Firefox provided by Mozilla Foundation of Mountain View, Calif.). Clients **102** may also access SaaS resources through smartphone or tablet applications, including, e.g., Salesforce Sales Cloud, or Google Drive app. Clients **102** may also access SaaS resources through the client operating system, including, e.g., Windows file system for DROPBOX.

In some embodiments, access to IaaS, PaaS, or SaaS resources may be authenticated. For example, a server or authentication server may authenticate a user via security certificates, HTTPS, or API keys. API keys may include various encryption standards such as, e.g., Advanced Encryption Standard (AES). Data resources may be sent over Transport Layer Security (TLS) or Secure Sockets Layer (SSL).

The client **102** and server **106** may be deployed as and/or executed on any type and form of computing device, e.g. a computer, network device or appliance capable of communicating on any type and form of network and performing the operations described herein. FIGS. **1**C and **1**D depict block diagrams of a computing device **100** useful for practicing an embodiment of the client **102** or a server **106**. As shown in FIGS. **1**C and **1**D, each computing device **100** includes a central processing unit **121**, and a main memory unit **122**. As shown in FIG. **1**C, a computing device **100** may include a storage device **128**, an installation device **116**, a network interface **118**, an I/O controller **123**, display devices **124***a*-**124***n*, a keyboard **126** and a pointing device **127**, e.g. a mouse. The storage device **128** may include, without limitation, an operating system, software, and a software of a network security tool **120**. As shown in FIG. **1**D, each computing device **100** may also include additional optional elements, e.g. a memory port **103**, a bridge **170**, one or more input/output devices **130***a*-**130***n* (generally referred to using reference numeral **130**), and a cache memory **140** in communication with the central processing unit **121**.

The central processing unit **121** is any logic circuitry that responds to and processes instructions fetched from the main memory unit **122**. In many embodiments, the central processing unit **121** is provided by a microprocessor unit, e.g.: those manufactured by Intel Corporation of Mountain View, Calif.; those manufactured by Motorola Corporation of Schaumburg, Ill.; the ARM processor and TEGRA system on a chip (SoC) manufactured by Nvidia of Santa Clara, Calif.; the POWER7 processor, those manufactured by International Business Machines of White Plains, N.Y.; or those manufactured by Advanced Micro Devices of Sunnyvale, Calif. The computing device **100** may be based on any of these processors, or any other processor capable of operating as described herein. The central processing unit **121** may utilize instruction level parallelism, thread level parallelism, different levels of cache, and multi-core processors. A multi-core processor may include two or more processing units on a single computing component. Examples of multi-core processors include the AMD PHENOM IIX2, INTEL CORE i5 and INTEL CORE i7.

Main memory unit **122** may include one or more memory chips capable of storing data and allowing any storage location to be directly accessed by the microprocessor **121**. Main memory unit **122** may be volatile and faster than storage **128** memory. Main memory units **122** may be Dynamic random access memory (DRAM) or any variants, including static random access memory (SRAM), Burst SRAM or SynchBurst SRAM (BSRAM), Fast Page Mode DRAM (FPM DRAM), Enhanced DRAM (EDRAM), Extended Data Output RAM (EDO RAM), Extended Data Output DRAM (EDO DRAM), Burst Extended Data Output DRAM (BEDO DRAM), Single Data Rate Synchronous DRAM (SDR SDRAM), Double Data Rate SDRAM (DDR SDRAM), Direct Rambus DRAM (DRDRAM), or Extreme Data Rate DRAM (XDR DRAM). In some embodiments, the main memory **122** or the storage **128** may be non-volatile; e.g., non-volatile read access memory (NVRAM), flash memory non-volatile static RAM (nvSRAM), Ferroelectric RAM (FeRAM), Magnetoresistive RAM (MRAM), Phase-change memory (PRAM), conductive-bridging RAM (CBRAM), Silicon-Oxide-Nitride-Oxide-Silicon (SONOS), Resistive RAM (RRAM), Racetrack, Nano-RAM (NRAM), or Millipede memory. The main memory **122** may be based on any of the above described memory chips, or any other available memory chips capable of operating as described herein. In the embodiment shown in FIG. **1**C, the processor **121** communicates with main memory **122** via a system bus **150** (described in more detail below). FIG. **1**D depicts an embodiment of a computing device **100** in which the processor communicates directly with main memory **122** via a memory port **103**. For example, in FIG. **1**D the main memory **122** may be DRDRAM.

FIG. **1**D depicts an embodiment in which the main processor **121** communicates directly with cache memory **140** via a secondary bus, sometimes referred to as a backside bus. In other embodiments, the main processor **121** communicates with cache memory **140** using the system bus **150**. Cache memory **140** typically has a faster response time than main memory **122** and is typically provided by SRAM, BSRAM, or EDRAM. In the embodiment shown in FIG. **1**D, the processor **121** communicates with various I/O devices **130** via a local system bus **150**. Various buses may be used to connect the central processing unit **121** to any of the I/O devices **130**, including a PCI bus, a PCI-X bus, or a PCI-Express bus, or a NuBus. For embodiments in which the I/O device is a video display **124**, the processor **121** may use an Advanced Graphics Port (AGP) to communicate with the display **124** or the I/O controller **123** for the display **124**. FIG. **1**D depicts an embodiment of a computer **100** in which the main processor **121** communicates directly with I/O device **130***b* or other processors **121'** via HYPERTRANSPORT, RAPIDIO, or INFINIBAND communications technology. FIG. **1**D also depicts an embodiment in which local busses and direct communication are mixed: the processor **121** communicates with I/O device **130***a* using a local interconnect bus while communicating with I/O device **130***b* directly.

A wide variety of I/O devices **130***a*-**130***n* may be present in the computing device **100**. Input devices may include keyboards, mice, trackpads, trackballs, touchpads, touch mice, multi-touch touchpads and touch mice, microphones, multi-array microphones, drawing tablets, cameras, single-lens reflex camera (SLR), digital SLR (DSLR), CMOS sensors, accelerometers, infrared optical sensors, pressure sensors, magnetometer sensors, angular rate sensors, depth sensors, proximity sensors, ambient light sensors, gyroscopic sensors, or other sensors. Output devices may include video displays, graphical displays, speakers, headphones, inkjet printers, laser printers, and 3D printers.

Devices **130***a*-**130***n* may include a combination of multiple input or output devices, including, e.g., Microsoft KINECT, Nintendo Wiimote for the WII, Nintendo WII U GAMEPAD, or Apple IPHONE. Some devices **130***a*-**130***n* allow gesture recognition inputs through combining some of the inputs and outputs. Some devices **130***a*-**130***n* provides for facial recognition which may be utilized as an input for different purposes including authentication and other commands. Some devices **130***a*-**130***n* provides for voice recognition and inputs, including, e.g., Microsoft KINECT, SIRI for IPHONE by Apple, Google Now or Google Voice Search.

Additional devices **130***a*-**130***n* have both input and output capabilities, including, e.g., haptic feedback devices, touchscreen displays, or multi-touch displays. Touchscreen, multi-touch displays, touchpads, touch mice, or other touch sensing devices may use different technologies to sense touch, including, e.g., capacitive, surface capacitive, projected capacitive touch (PCT), in-cell capacitive, resistive, infrared, waveguide, dispersive signal touch (DST), in-cell optical, surface acoustic wave (SAW), bending wave touch (BWT), or force-based sensing technologies. Some multi-touch devices may allow two or more contact points with the surface, allowing advanced functionality including, e.g., pinch, spread, rotate, scroll, or other gestures. Some touchscreen devices, including, e.g., Microsoft PIXELSENSE or Multi-Touch Collaboration Wall, may have larger surfaces, such as on a table-top or on a wall, and may also interact with other electronic devices. Some I/O devices **130***a*-**130***n*, display devices **124***a*-**124***n* or group of devices may be augment reality devices. The I/O devices may be controlled by an I/O controller **123** as shown in FIG. **1**C. The I/O controller may control one or more I/O devices, such as, e.g., a keyboard **126** and a pointing device **127**, e.g., a mouse or optical pen. Furthermore, an I/O device may also provide storage and/or an installation medium **116** for the computing device **100**. In still other embodiments, the computing device **100** may provide USB connections (not shown) to receive handheld USB storage devices. In further embodiments, an I/O device **130** may be a bridge between the system bus **150** and an external communication bus, e.g. a USB bus, a SCSI bus, a FireWire bus, an Ethernet bus, a Gigabit Ethernet bus, a Fibre Channel bus, or a Thunderbolt bus.

In some embodiments, display devices **124***a*-**124***n* may be connected to I/O controller **123**. Display devices may include, e.g., liquid crystal displays (LCD), thin film transistor LCD (TFT-LCD), blue phase LCD, electronic papers (e-ink) displays, flexile displays, light emitting diode displays (LED), digital light processing (DLP) displays, liquid crystal on silicon (LCOS) displays, organic light-emitting diode (OLED) displays, active-matrix organic light-emitting diode (AMOLED) displays, liquid crystal laser displays, time-multiplexed optical shutter (TMOS) displays, or 3D displays. Examples of 3D displays may use, e.g. stereoscopy, polarization filters, active shutters, or autostereoscopy. Display devices **124***a*-**124***n* may also be a head-mounted display (HMD). In some embodiments, display devices **124***a*-**124***n* or the corresponding I/O controllers **123** may be controlled through or have hardware support for OPENGL or DIRECTX API or other graphics libraries.

In some embodiments, the computing device **100** may include or connect to multiple display devices **124***a*-**124***n*, which each may be of the same or different type and/or form. As such, any of the I/O devices **130***a*-**130***n* and/or the I/O controller **123** may include any type and/or form of suitable hardware, software, or combination of hardware and software to support, enable or provide for the connection and use of multiple display devices **124***a*-**124***n* by the computing device **100**. For example, the computing device **100** may include any type and/or form of video adapter, video card, driver, and/or library to interface, communicate, connect or otherwise use the display devices **124***a*-**124***n*. In one embodiment, a video adapter may include multiple connectors to interface to multiple display devices **124***a*-**124***n*. In other embodiments, the computing device **100** may include multiple video adapters, with each video adapter connected to one or more of the display devices **124***a*-**124***n*. In some embodiments, any portion of the operating system of the computing device **100** may be configured for using multiple displays **124***a*-**124***n*. In other embodiments, one or more of the display devices **124***a*-**124***n* may be provided by one or more other computing devices **100***a* or **100***b* connected to the computing device **100**, via the network **104**. In some embodiments software may be designed and constructed to use another computer's display device as a second display device **124***a* for the computing device **100**. For example, in one embodiment, an Apple iPad may connect to a computing device **100** and use the display of the device **100** as an additional display screen that may be used as an extended desktop. One ordinarily skilled in the art will recognize and appreciate the various ways and embodiments that a computing device **100** may be configured to have multiple display devices **124***a*-**124***n*.

Referring again to FIG. **1**C, the computing device **100** may comprise a storage device **128** (e.g. one or more hard disk drives or redundant arrays of independent disks) for storing an operating system or other related software, and for storing application software programs such as any program related to the software **120** for the network security tool. Examples of storage device **128** include, e.g., hard disk drive (HDD); optical drive including CD drive, DVD drive, or BLU-RAY drive; solid-state drive (SSD); USB flash drive; or any other device suitable for storing data. Some storage devices may include multiple volatile and non-volatile memories, including, e.g., solid state hybrid drives that combine hard disks with solid state cache. Some storage device **128** may be non-volatile, mutable, or read-only. Some storage device **128** may be internal and connect to the computing device **100** via a bus **150**. Some storage device **128** may be external and connect to the computing device **100** via a I/O device **130** that provides an external bus. Some storage device **128** may connect to the computing device **100** via the network interface **118** over a network **104**, including, e.g., the Remote Disk for MACBOOK AIR by Apple. Some client devices **100** may not require a non-volatile storage device **128** and may be thin clients or zero clients **102**. Some storage device **128** may also be used as an installation device **116**, and may be suitable for installing software and programs. Additionally, the operating system and the software can be run from a bootable medium, for example, a bootable CD, e.g. KNOPPIX, a bootable CD for GNU/Linux that is available as a GNU/Linux distribution from knoppix.net.

Client device **100** may also install software or application from an application distribution platform. Examples of application distribution platforms include the App Store for iOS provided by Apple, Inc., the Mac App Store provided by Apple, Inc., GOOGLE PLAY for Android OS provided by Google Inc., Chrome Webstore for CHROME OS provided by Google Inc., and Amazon Appstore for Android OS and KINDLE FIRE provided by Amazon.com, Inc. An application distribution platform may facilitate installation of software on a client device **102**. An application distribution platform may include a repository of applications on a server **106** or a cloud **108**, which the clients **102***a*-**102***n* may access over a network **104**. An application distribution platform may include application developed and provided by various developers. A user of a client device **102** may select, purchase and/or download an application via the application distribution platform.

Furthermore, the computing device **100** may include a network interface **118** to interface to the network **104** through a variety of connections including, but not limited to, standard telephone lines LAN or WAN links (e.g., 802.11, T1, T3, Gigabit Ethernet, Infiniband), broadband connections (e.g., ISDN, Frame Relay, ATM, Gigabit Ethernet, Ethernet-over-SONET, ADSL, VDSL, BPON, GPON, fiber optical including FiOS), wireless connections, or some combination of any or all of the above. Connections can be established using a variety of communication protocols (e.g., TCP/IP, Ethernet, ARCNET, SONET, SDH, Fiber Distributed Data Interface (FDDI), IEEE 802.11a/b/g/n/ac CDMA, GSM, WiMax and direct asynchronous connections). In one embodiment, the computing device **100** communicates with other computing devices **100'** via any type and/or form of gateway or tunneling protocol e.g. Secure Socket Layer (SSL) or Transport Layer Security (TLS), or the Citrix Gateway Protocol manufactured by Citrix Systems, Inc. of Ft. Lauderdale, Fla. The network interface **118** may comprise a built-in network adapter, network interface card, PCMCIA network card, EXPRESSCARD network card, card bus network adapter, wireless network adapter, USB network adapter, modem or any other device suitable for interfacing the computing device **100** to any type of network capable of communication and performing the operations described herein.

A computing device **100** of the sort depicted in FIGS. **1**B and **1**C may operate under the control of an operating system, which controls scheduling of tasks and access to system resources. The computing device **100** can be running any operating system such as any of the versions of the MICROSOFT WINDOWS operating systems, the different releases of the Unix and Linux operating systems, any version of the MAC OS for Macintosh computers, any embedded operating system, any real-time operating system, any open source operating system, any proprietary operating system, any operating systems for mobile computing devices, or any other operating system capable of running on the computing device and performing the operations described herein. Typical operating systems include, but are not limited to: WINDOWS 2000, WINDOWS Server 2012, WINDOWS CE, WINDOWS Phone, WINDOWS XP, WINDOWS VISTA, and WINDOWS 7, WINDOWS RT, and WINDOWS 8 all of which are manufactured by Microsoft Corporation of Redmond, Wash.; MAC OS and iOS, manufactured by Apple, Inc. of Cupertino, Calif.; and Linux, a freely-available operating system, e.g. Linux Mint distribution ("distro") or Ubuntu, distributed by Canonical Ltd. of London, United Kingom; or Unix or other Unix-like derivative operating systems; and Android, designed by Google, of Mountain View, Calif., among others. Some operating systems, including, e.g., the CHROME OS by Google, may be used on zero clients or thin clients, including, e.g., CHROMEBOOKS.

The computer system **100** can be any workstation, telephone, desktop computer, laptop or notebook computer, netbook, ULTRABOOK, tablet, server, handheld computer, mobile telephone, smartphone or other portable telecommunications device, media playing device, a gaming system, mobile computing device, or any other type and/or form of computing, telecommunications or media device that is capable of communication. The computer system **100** has sufficient processor power and memory capacity to perform the operations described herein. In some embodiments, the computing device **100** may have different processors, operating systems, and input devices consistent with the device. The Samsung GALAXY smartphones, e.g., operate under the control of Android operating system developed by Google, Inc. GALAXY smartphones receive input via a touch interface.

In some embodiments, the computing device **100** is a gaming system. For example, the computer system **100** may comprise a PLAYSTATION 3, or PERSONAL PLAYSTATION PORTABLE (PSP), or a PLAYSTATION VITA device manufactured by the Sony Corporation of Tokyo, Japan, a NINTENDO DS, NINTENDO 3DS, NINTENDO WII, or a NINTENDO WII U device manufactured by Nintendo Co., Ltd., of Kyoto, Japan, an XBOX 360 device manufactured by the Microsoft Corporation of Redmond, Wash.

In some embodiments, the computing device **100** is a digital audio player such as the Apple IPOD, IPOD Touch, and

IPOD NANO lines of devices, manufactured by Apple Computer of Cupertino, Calif. Some digital audio players may have other functionality, including, e.g., a gaming system or any functionality made available by an application from a digital application distribution platform. For example, the IPOD Touch may access the Apple App Store. In some embodiments, the computing device **100** is a portable media player or digital audio player supporting file formats including, but not limited to, MP3, WAV, M4A/AAC, WMA Protected AAC, RIFF, Audible audiobook, Apple Lossless audio file formats and .mov, .m4v, and .mp4 MPEG-4 (H.264/MPEG-4 AVC) video file formats.

In some embodiments, the computing device **100** is a tablet e.g. the IPAD line of devices by Apple; GALAXY TAB family of devices by Samsung; or KINDLE FIRE, by Amazon.com, Inc. of Seattle, Wash. In other embodiments, the computing device **100** is an eBook reader, e.g. the KINDLE family of devices by Amazon.com, or NOOK family of devices by Barnes & Noble, Inc. of New York City, New York.

In some embodiments, the communications device **102** includes a combination of devices, e.g. a smartphone combined with a digital audio player or portable media player. For example, one of these embodiments is a smartphone, e.g. the IPHONE family of smartphones manufactured by Apple, Inc.; a Samsung GALAXY family of smartphones manufactured by Samsung, Inc; or a Motorola DROID family of smartphones. In yet another embodiment, the communications device **102** is a laptop or desktop computer equipped with a web browser and a microphone and speaker system, e.g. a telephony headset. In these embodiments, the communications devices **102** are web-enabled and can receive and initiate phone calls. In some embodiments, a laptop or desktop computer is also equipped with a webcam or other video capture device that enables video chat and video call.

In some embodiments, the status of one or more machines **102**, **106** in the network **104** are monitored, generally as part of network management. In one of these embodiments, the status of a machine may include an identification of load information (e.g., the number of processes on the machine, CPU and memory utilization), of port information (e.g., the number of available communication ports and the port addresses), or of session status (e.g., the duration and type of processes, and whether a process is active or idle). In another of these embodiments, this information may be identified by a plurality of metrics, and the plurality of metrics can be applied at least in part towards decisions in load distribution, network traffic management, and network failure recovery as well as any aspects of operations of the present solution described herein. Aspects of the operating environments and components described above will become apparent in the context of the systems and methods disclosed herein.

B. Network Security Tool

Systems and method of the present solution are directed to a self-tuning network security tool that facilitates automatically identifying a current vulnerability of a computer system or network, and preventing an attack from exploiting the current vulnerability. The network security tool may include, use or have access to Vulnerability Assessment (VA) tools and Intrusion Detection and Prevention Systems (IDS/IPS), and facilitate the management and collation of the knowledge that is generated by these tools or systems.

In brief overview, and in some embodiments, a vulnerability may refer to a weakness in software, hardware, or firmware of a system. Such weakness might allow an adversary to violate the confidentiality, the availability, and the integrity of the system, its processes/applications, as well as, the data the system generate and manage. In network security, vulnerability may refer to the weakness of a network device/station that could allow unauthorized intrusion in the network. Further, human weaknesses regarding the information security sensitivity are considered as vulnerabilities that can be exploited by social engineering techniques. In security industry, there are a plethora of vulnerability schemes and registries specified, generated, and maintained by various enterprises, organizations or research institutions. Such registries for instance are the CERT Advisories maintained by the Software Engineering Institute at Carnegie Mellon University of Pittsburgh, Pa., the CVE scheme maintained by MITRE Corporation of Bedford, Mass., the Bugtraq vulnerability list maintained by Security Focus of SYMANTEC CORPORATION of Mountain View, Calif. Various entities, corporations, or software firms may also maintain public vulnerabilities registries regarding the products they develop in relevant web sites. In various embodiments, the tool can be configured to receive, access, look up, process, analyze or otherwise obtain and utilize information of one or more vulnerabilities lists or registries in one or more formats, standards, or schemes. For example, the tool can be configured to use the CVE vulnerability scheme created by MITRE Corporation. However, in some embodiments, the tool can be vulnerability scheme independent.

In some embodiments, an exploit refers to a piece of software, a chunk of data, or a sequence of commands that takes advantage of a bug or vulnerability in order to cause computer software and/or hardware to have unintended or unanticipated behavior. Such behavior may aim to gain control of a system, allowing privilege escalation, or a denial-of-service attack. Signatures can refer to attack patterns that are used by the tool. The signatures, or patterns, specify attacks in a network, a network node, a networked device, at a host level.

The tool can be deployed to identify cases of illegitimate behavior and/or utilization of a system at runtime. To do so, the tool can differentiate between legitimate and illegitimate behavior and utilization, including, e.g., misuse-based or signature based behaviors. For example, the tool can use a known set of misuse patterns, or signatures, to filter execution traces. Signatures can be generated by focusing on a limited amount of information that was sufficient to distinguish an attack from a legitimate use of the network or system in the past.

To minimize false negatives, i.e., failure to identify some illegitimate behaviors, and false positives, i.e., wrong identification of some legitimate behaviors as illegitimate, the tool can maintain an up-to-date library of misuse patterns or signatures. Therefore, the tool can mitigate, prevent, or minimize the likelihood of new legitimate uses being identified as misuses, i.e., false positives, and the tool can refine the signatures to distinguish them from illegitimate uses.

A VA tool can assess the vulnerabilities of one or more system or one or more network to generate great volumes of network defense information regarding the security weaknesses of the examined system or network. The network security tool can use the information generated by the VA tool to provide coherence, connection and/or correlation for a system in order to provide a holistic view of vulnerabilities that could be taken into account for the efficient confrontation of the system vulnerabilities. Thus, the network security tool of the present disclosure can automatically implement a plan of action to address findings of the VA tool. For example, the network security tool can provide context and coherence with regard to maintenance, ground, and sound structuring of network defense information by dynamically assessing vulnerabilities in context with a current a network and by taking into account settings of the underlying infrastructure of the examined network and the actual risk posed by the identified vulnerabilities. Further, the tool can generate and store security events in a correlated manner. For example, predictive computations on attack graphs can be used to map vulnerability paths, which might be chosen as attack activities by adversaries. Based on attack paths, strategies for protecting critical network assets can be computed.

In some embodiments, the network security tool can obtain, identify, or collect security information related to vulnerabilities, exploits and IDS/IPS signatures. The tool can collect security information related to vulnerabilities, exploits and IDS/IPS signatures from a large number of sources (Web, mailing lists, hacking websites, security systems, vulnerability scanning reports, specific tools like SNORT of CISCO Corporation of San Jose, Calif.), and store them in one or more databases. The tool may then normalize the vulnerability information (e.g. redundant data may be de-duplicated) and correlate the vulnerability information with relative exploit code or IDS/IPS signatures. When the tool **120** parses a report from a VA tool (e.g., Open Vulnerability Assessment System ("OpenVAS") which is a framework of several services and tools offering a vulnerability scanning and vulnerability management solution), the tool can identify current vulnerabilities. In some embodiments, the tool may construct the attack and response paths for the identified vulnerabilities using Topological Vulnerability Analysis techniques, score one or more (some or all) identified vulnerability using a Common Vulnerability Scoring System from 0 to 10 (e.g., CVSSv2 which is an industry standard for assessing the severity of computer system vulnerabilities and maintained by the National Infrastructure Advisory Council of the United States of America) and provide the IDS/IPS signature(s) required to confront this particular attack. Thus, the tool can used as a proactive security mechanism (e.g. during the vulnerability analysis of a network infrastructure) and as an ongoing, continuous self-tuning mechanism. Moreover the tool can be used for efficiently and effectively tuning the IDS systems according to the unique security requirements of the network infrastructure.

Referring to FIG. **3**, a process **300** of self-tuning a network intrusion and detection system via a network security tool is shown. At step **305**, an update service of the tool receives updates on the latest vulnerabilities, exploits and signatures via a resource accessed by a network (e.g., Internet, World Wide Web). These updates may be identified and provided by a security community and generally applicable to networks or systems. At step **315**, a vulnerability assessment tool scans the protected network (e.g., the private network the method **300** is attempting to protect) to generate a list of vulnerabilities that are identified within the network, including, e.g., on network devices, operating systems, desktop applications, Web applications, databases, etc. At step **335**, a real time monitoring and log management process obtains, identifies, receives or otherwise captures activities logs that occur at the runtime of the network. A log normalization process **340** receives this activities log information from process **335** and transforms the logs to vulnerabilities formatted under a common scheme (e.g., the common scheme used at step **315** by vulnerabilities assessment tool to report or provide the vulnerabilities to the optimization process **400**). At step **325**, the process determines information regarding the history of mitigated or active vulnerabilities with the protected network (e.g., if the threat is mitigated or if the threat is not mitigated).

At step **400**, an optimization process of the tool receives the updates on vulnerabilities, exploits and signatures from the update service **305** and the identified current vulnerabilities in the protected network as identified by the vulnerability assessment at step **315**. In some embodiments, at step **400**, the optimization process receives the information or logs regarding the history of mitigated or active vulnerabilities within the network via processes **325**, **340** and **335**.

The optimization process **400** (which is shown in FIG. **4**) may receive the information via a real-time data feed, streaming data feed, push, pull, network communication, internal system communication, via a network interface, a user interface (e.g., graphical user interface), etc. For example, the optimization process **400** uses the vulnerabilities list generated by the vulnerability assessment at step **315** by scanning the protected network, and the latest vulnerabilities, exploits and signature updates as they occur on the World Wide Web and provided by the security community at step **305**. Further, and in some embodiments, these inputs to the optimization process **400** may be provided in a common scheme to allow the optimization process to correlate the information. For example, a common scheme may include the standard for Information Security Vulnerability Names, referred to as Common Vulnerabilities and Exposures ("CVE").

Referring to FIG. **2**, an embodiment of a system **200** including a network security tool is depicted. In brief overview, the system **200** includes one or more clients **102***a-n* (e.g., end user devices, computing devices, administrator devices) or servers **106***a-n* that communicate via a private or protected network **204**. In some embodiments, network **204** may be similar to network **104**, except that is a protected or private network in that it may not be accessible to the general public or confined to a company, organization or entity. The system **200** may include or have access to one or more security intelligence repositories **202***a-n*, such as a Worldwide security Repository, via an external network **104**. The system **200** may include a network security tool **120**. The tool **120** can be designed and constructed to perform one or more self-tuning network intrusion, detection and prevention functions. In some embodiments, the tool **120** includes an interface **205**, vulnerability assessor **210**, network security device **215**, intrusion detector **220**, update service **225** and database **230**. In some embodiments, the tool **120** may not include a vulnerability assessor **210**; rather, the tool **120** may receive a vulnerabilities list from a vulnerability assessment tool via a protected network **204** or an external network **104**, or otherwise obtain a vulnerabilities list. In some embodiments, the network security device **215** is designed and constructed to perform one or more self-tuning or optimization functions, as described in FIG. **4**. In some embodiments, the intrusion detector **220** can include an IDS/IPS system. The tool **120** may include one or more components **205**, **210**, **215**, **220**, **225**, and **230**. Each component may execute on, include or have access to one or more processor, logic array, circuitry, or other components as shown in FIGS. **1A-1D**.

In further detail, the tool **120** can include an interface **205**. The interface **205** can be designed and constructed to communicate via a protected network **204** or an external network **104**. A protected network **204** may refer to a private network, e.g., a network that the network security tool **120** is attempting to protect. For example, this network may refer to an internal network, or intranet, of a company, organization, university, or other entity. In some embodiments, the interface **205** is designed and constructed to communicate via an external network **104**, such as the World Wide Web or Internet. In some embodiments, the interface **205** facilitates interaction or communication between one or more modules or components of, or associated with, the tool **120**, such as vulnerability assessor **210**, network security device **215**, intrusion detector **220**, update service **225**, or database or repository **230**.

In some embodiments, the network security tool **120** includes a vulnerability assessor **210**. In some embodiments, the vulnerability assessor **210** can identify a current vulnerability of a private network and determine a signature of an attack configured to exploit the current vulnerability. A vulnerability assessor may refer to a vulnerability assessment tool, such as WIRESHARK, NMAP, METASPLOIT, OPENVAS, AIRCRACK. In some embodiments, the vulnerability assessor **210** can include a vulnerability scanner. The vulnerability assessor **210** can be designed and constructed to capture traffic of a TCP broadcast domain and apply one or more filters to intercept or identify certain traffic (e.g., between clients **102***a-n*, servers **106***a-n*, or simulated packets by the tool **120** or other device). For example, the vulnerability assessor **210** can obtain data packets of a protected network, save the data packets to a data file or database, and analyze the data packets to identify stray IP addresses, spoofed packets, unnecessary packet drops, or suspicious packet generation from a single IP address. In some embodiments, the vulnerability assessor **210** can craft data packets and perform scans on a granular TCP level, such as a SYN scan, ACK scan, etc. In some embodiments, the vulnerability assessor **210** can determine the operating system and version, based on network responses such as a TCP handshake. Further, the vulnerability assessor **210** can determine which ports are open and whether these open ports can be exploited. Using various vulnerability assessment and scanning techniques, the vulnerability assessor **210** can provide, create, generate or otherwise identify a list of vulnerabilities of the protected network **204**. The vulnerabilities list can be stored in database **230** in memory or provided to one or more component of the tool **120** for further processing.

In some embodiments, the vulnerability assessor **210** can perform real time monitoring of data packets of the network **204**. In some embodiments, network security tool **120** may include a passive vulnerability assessor configured to perform real monitoring of network traffic or analyze activities logs. In some embodiments, the vulnerability assessor **210** may include a passive vulnerability assessor, or be configured to perform a function thereof (e.g., the network security tool may use a separate vulnerability assessment tool that may perform a routine assessment of vulnerabilities and provide the vulnerabilities list to the network security tool, and/or the network security tool may continuously passively monitor network traffic in real-time to identify vulnerabilities). In some embodiments, the tool **120** can obtain or aggregate activity logs from one or more client **102***a-n* or server **106***a-n*. In some embodiments, the vulnerability assessors may include a Security Incident and Event Manager (SIEM) designed and constructed to store and interpret logs or events generated by software running on a data network. In some embodiments, the tool may include a separate component that performs one or more monitoring or SIEM function.

In some embodiments, the tool **120** can perform passive vulnerability assessment based on log sets generated by the real time monitoring component of the tool. For example, this real time monitoring may be performed by the component of the tool that translates logs from **410** to update **420** repository as depicted in FIG. **4**. The translation of the outcome of a real time monitoring process can emulate a passive vulnerability assessment process. For example, and in some embodiments, the tool can alter an active vulnerabilities repository responsive to real time monitoring of network traffic or activities logs generating, identifying, obtaining or otherwise providing an update to the active vulnerabilities repository. For example, the tool can perform real time monitoring to identify a mitigated or active vulnerability.

For example, and in some embodiments, the tool can identify a first vulnerability by receiving the information about the first vulnerability by a vulnerability assessment tool that performed a periodic vulnerability assessment on the private network. The tool may additionally perform a passive vulnerability assessment on the network by continuously monitoring network traffic of the private network via one or more activity logs. Based on this passive, continuous monitoring, the tool may identify a second current vulnerability of the private network. The tool may then determine a second signature of a second attack configured to exploit the second current vulnerability, compare the second signature with the active and inactive signatures stored in the signature repository. Based on the comparison, the tool may determine that the second signature corresponds to an active signature stored in the signature repository. Thereafter, the tool (e.g., via the intrusion detector) can use the active signature corresponding to the second signature to identify a second exploit based on data packets received via the private network. The tool may also use the active signature for the first signature to identify exploits. For example, the tool may provide these active signatures to an IDS/IPS system.

The vulnerability assessor **210** can be configured to perform a log normalization function in order to translate, format or alter the log information such that it conforms to a common vulnerability scheme or standard. In some embodiments, the vulnerability assessor **210** can perform one or more functions associated with the optimization process **400** of FIG. **4** including, e.g., vulnerability assessment **400**, or real-time monitoring **410**.

In some embodiments, the tool **120** includes a network security device **215**. The network security device **215** can be designed and constructed to perform self-tuning functions using information such as a vulnerabilities list or other information related to known, active or inactive vulnerabilities, exploits and signature as obtained via the networks **204** or **104** or database **230**. The network security device **215** can, for example, be designed and constructed to perform one or more steps in of the optimization process **400** shown in FIG. **4**. For example, the network security device **215** can receive information from or generated by vulnerability assessor **210**, update service **225**, database **230**, or other resources accessible via interface **205** and networks **204** and **104**, such as security intelligence repositories **202***a-n*.

Using information about current vulnerabilities of the protected network **204**, the network security device **215** can compare a signature of an attack configured to exploit the current vulnerability with active or inactive signatures stored in a signature repository or database **230**. If the network security device **215** determines, based on the comparison, that the signature of the exploit of the current vulnerability is an inactive signature, then the network security device **215** can automatically activate the identified inactive signature of the exploit. In some embodiments, the network security device **215** can further determine whether an exploit exists for the current vulnerability and, if there is no known exploit for the vulnerability, the network security device **215** may not activate any signature.

In some embodiments, the network security device **215** can check each active signature in the database **230** to determine whether the active signature of a vulnerability or signature of an exploit of a vulnerability matches a current vulnerability of the protected network **204** or device of the protected network **204**. In some embodiments, a vulnerability of a protected network **204** can refer to a vulnerability associated with servers, computing devices, network nodes, systems, databases, etc. of the protected network **204**.

In some embodiments, the tool **120** includes an update service **225** designed and constructed to listen, periodically ping, receive, or otherwise obtain current or up-to-date information from a Worldwide security repository such as a security intelligence database or resource **202***a-n*. This information may be provided by a security community or crowd sourced, and accessed via an external network **104**. This security information can include, e.g., vulnerabilities, exploits, and signatures for same. The information may be time stamped or otherwise flagged so the tool **120** can determine if the information is new. In some embodiments, the tool **120** may receive a real-time data feed of security information. The update service **225** can perform one or more functions or steps associated with optimization process **400** including, e.g., update service **435**.

Referring now to FIG. **4**, an illustrative data flow for the optimization process **400** of a self-tuning network intrusion and detection system via a network security tool is shown. In some embodiments, the network security tool **120**, or one or more components, modules, or processors thereof, can be designed, constructed or configured to perform one or more steps of optimization process **400**. In brief overview, the optimization process **400** includes a main process **425**, a vulnerability assessment **405**, and real time monitoring **410**, and an update service **435**. The main process **425** can initiate or reinitiates the optimization procedure **400** by listening to activity demonstrated by the update service **435**, and Active Vulnerabilities Repository **420**. For example, to update the Known Vulnerabilities Exploits and Signatures Repository **440**, the update service **435** listens to new recorded vulnerabilities, exploits, and signatures that become known within the worldwide security community. For example, this information is illustrated abstractly by the Worldwide Security Intelligence Repository **430**.

In some embodiments, the main process **425** receives a notification when the update service **435** updates the known vulnerabilities, exploits, and signatures repository **440**. The notification may be any data communication that can notify the main process **425** of an update including, e.g., an alert, prompt, tag, indication, etc. Responsive to receiving the notification, the main process **425** can initiate the optimization procedure, in the event the main process was in an idle state, as shown in FIG. **5**.

In some embodiments, the main process **425** initiates or reinitiates the optimization procedure responsive to the active vulnerabilities repository **420** being updated. The active vulnerabilities repository **420** may be altered responsive to or after one or more activities occurs. In some embodiments, the active vulnerabilities repository **420** is altered responsive to the vulnerability assessment **405** being finalized. For example, the vulnerability assessment **405** process (e.g., performed by a vulnerability assessment tool) can generate outcome in the form of a Vulnerability List **415**. The vulnerability list **415** can be used to rewrite the active vulnerabilities repository **420** (as shown in FIG. **6**). In some embodiments, the active vulnerabilities repository **420** is altered responsive to real time monitoring **410** generating, identifying, obtaining or otherwise providing an update to the active vulnerabilities repository **420**. For example, the real time monitoring process **410** can identify a mitigated or active vulnerability. Thereafter, main process **425**, which is listening to the active vulnerabilities repository for such an update, can restart, initiate or reinitiate the optimization procedure **400**, e.g., in the event the procedure is idle (as shown in FIG. **7**).

In some embodiments, the main process **425** can be triggered to initiate or reinitiate the optimization procedure **400** when main process **425** updates the active vulnerabilities repository **420** by enabling signatures in the IDS/IPS of the protected system or generating alerts (as shown in FIG. **8**).

In further detail, the optimization process **400** includes performing a vulnerability assessment **405** to generate a vulnerability list **415**. In some embodiments, the optimization procedure includes receiving the generated vulnerability list **415**, rather than performing the vulnerability assessment (e.g., receiving the generated vulnerability list **415** from a vulnerability assessment tool via a network). The optimization process **400** can include real time monitoring **410**. The optimization process **400** can include the vulnerabilities list **415** and or the real time monitoring process **410** altering an active vulnerabilities repository **420**. For example, the vulnerability list **415** may initially overwrite the active vulnerabilities repository **420**, and the real time monitoring **420** may update the active vulnerability repository **420** in real-time, periodically, or upon triggering of an event or condition or other indication to update the active vulnerabilities repository **420**.

The optimization process **400** can include a main process **425** that initiates or reinitiates the optimization procedure. The main process **400** can listen to the active vulnerabilities repository **420** for an indication to initiate, reinitiate, restart or otherwise perform a function of the optimization procedure. The main process **425** can also listen to an update service **435**. The update service **435** can listen to a Worldwide Security Intelligence Repository **430** for any information regarding vulnerabilities, exploits, or signatures as identified by a security community or network security entities. Upon receiving an update from the Worldwide security intelligence repository **430**, the update service **435** can provide the information to the main process **425** or an indication of the new information, responsive to which the main process **425** may initiate or reinitiate or restart the optimization procedure **400**.

During the optimization procedure **400**, the network security tool can determine whether there is a new vulnerability **445**. For example, the main process **425** may receive or otherwise identify a potentially new vulnerability. The main process **425** may receive, get, request, or otherwise obtain or identify an update notifications from update service **435** or active vulnerabilities repository **420**. For each vulnerability V_i stored in the active vulnerabilities repository **420**, the tool can begin a check cycle starting at step **445**.

At step **445**, the tool determines whether vulnerability V_i is a new vulnerability. In some embodiments, the tool can check V_i against the vulnerabilities stored in the known vulnerabilities, exploits, and signatures repository **440** to determine whether V_i is a new vulnerability. For example, the tool can perform a lookup into the known vulnerabilities, exploits, and signatures repository **440** to determine whether the identified vulnerability is a new vulnerability. The tool may compare the potentially new vulnerability V_i with known vulnerabilities in repository **440** using a common scheme or standard. For example, the format for the vulnerability may be in a common scheme or use a common standard, or may be normalized or otherwise translated or reformatted such that the comparison of vulnerabilities is accurate.

In the event that V_i is not a new vulnerability, at step **450**, V_i can be checked against the active vulnerabilities repository **420** to determine whether V_i is still an active vulnerability of the protected system (e.g., by performing a lookup into the active vulnerabilities repository **420**). If $V_{i\ is}$ not an active vulnerability, the procedure disables one or more signatures related to V_i in the IDS/IPS of the protected system at step **455**.

However, if V_i is determined to be an active or new vulnerability (e.g., V_i exists in the active vulnerabilities repository

420), the process **400** can include performing, at step **475**, a lookup in the known vulnerabilities, exploits and signature repository **440** to determine whether there is a relevant exploit E_i for vulnerability V_i. In the event the tool determines there is a known exploit E_i for V_i, (e.g., an exploit is found at step **465** and this information is fed or provided to process **485**), and in some embodiments, the process **400** includes, at step **485**, searching, parsing, performing a lookup or otherwise identifying a signature S_i for exploit E_i using the known vulnerabilities, exploits and signatures repository **440**. If the tool identifies a relevant signature S_i for the exploit E_i, the process **400** can include enabling S_i by appending S_i to the signature list of the IDS/IPS of the protected system at step **480**.

If the tool determines at step **485** that a signature does not exist for the exploit, the process can include determining whether a signature can be generated for the exploit at step **490**. For example, signatures can be generated using various techniques including, e.g., statistical packet anomaly detection engine, Hamsa: fast signature generation for zero-day polymorphic worms with provable attack resilience, Polygraph: automatically generating signatures for polymorphic worms, dynamic taint analysis for automatic signature generation of exploits on commodity software, honeycomb—creating intrusion detection signatures using honeypots, automatic generation of buffer overflow attack signatures based on behavior models, Petri net-based signatures, etc. If S_i can be generated, the tool creates the signature at step **490** and enables it in the IDS/IPS of the protected system at step **480**. Otherwise, the tool generates an alert at step **470** and provides, transmits, or otherwise conveys the alert to a system administrator via a user interface.

At step **460**, if the tool determines that there is not a known exploit E_i for V_i, the process can include searching the known vulnerabilities, exploits and signatures repository **440** to determine whether there is a signature S_i for V_i at step **475**. If the tool identifies an S_i at step **475**, the tool enables S_i by appending S_i to the signature list of the IDS/IPS of the protected system at step **480**. It should be noted that in case that there is no signature at step **475**, (e.g., there is no known relevant E_i nor S_i for V_i), the process may do nothing because V_i may be a vulnerability of the protected system with unknown exploitation methods (e.g., if an exploit for the vulnerability does not exist then an attacker may not be able to take advantage of the vulnerability yet).

Referring to FIG. **5**, an embodiment of a method **500** of self-tuning a network intrusion, detection and prevention system is shown. In some embodiments, the network security tool **120**, or one or more components, modules, or processors thereof, can be designed, constructed or configured to perform one or more steps of process **500**. In some embodiments, method **500** may be performed at, during, or in associated with step **435** shown in FIG. **4**. In some embodiments, FIG. **5** can represent an illustrative sequence diagram that results in initiating, reinitiating or restarting the optimization process shown in FIG. **4**. At step **505**, a Worldwide Security Repository can receive a new security item, such as a vulnerability, exploit, or signature for same, and record this information in the repository (e.g., as shown in step **430** of FIG. **4**). At step **510**, an update service may receive the new security item via a real-time data feed, periodic data feed, notification, alert, prompt, email, or other communication (e.g., as shown in step **435** of FIG. **4**). At step **515**, a main process may receive a notification of the update (e.g., as shown in step **425** of FIG. **4**). Responsive to receiving the notification of the update, the tool may initiate or reinitiate the main process if the main process was in an idle state (e.g., as shown in step **425** of FIG. **4**). At step **520**, the main process may proceed to checking known vulnerabilities, exploits and signatures (e.g., as shown in step **440** of FIG. **4**).

Referring to FIG. **6**, an embodiment of a method **600** of self-tuning a network intrusion, detection and prevention system is shown. In some embodiments, the network security tool **120**, or one or more components, modules, or processors thereof, can be designed, constructed or configured to perform one or more steps of process **600**. In some embodiments, method **600** may be performed at, during, or in associated with step **405** shown in FIG. **4**. In some embodiments, FIG. **6** can represent an illustrative sequence diagram that results in initiating, reinitiating or restarting the optimization process shown in FIG. **4**.

In some embodiments, at step **605**, the method starts by performing a vulnerability assessment or obtaining security information from a vulnerability assessment. For example, the tool may compute vulnerabilities of a private or protected network using one or more vulnerability assessment or vulnerability scanning techniques. If the vulnerability assessment identifies one or more vulnerabilities, the identified vulnerability and/or signature for same can be stored in an active vulnerabilities repository at step **610** (e.g., similar to step **420** of FIG. **4**). Responsive to storing, providing, or otherwise identifying an active vulnerability, the tool can initiate a main process (e.g., optimization process **425** of FIG. **4**) at step **615**.

Referring to FIG. **7**, an embodiment of a method **700** of self-tuning a network intrusion, detection and prevention system is shown. In some embodiments, the network security tool **120**, or one or more components, modules, or processors thereof, can be designed, constructed or configured to perform one or more steps of process **700**. In some embodiments, method **700** may be performed at, during, or in associated with step **410** shown in FIG. **4**. In some embodiments, FIG. **7** can represent an illustrative sequence diagram that results in initiating, reinitiating or restarting the optimization process shown in FIG. **4**.

At step **705**, the tool can perform real time monitoring of a protected network by analyzing network traffic, data packets, or aggregated activities logs to identify vulnerabilities. Upon identifying an active vulnerability, the tool can store the vulnerability in an active vulnerabilities repository at step **710**. At step **715**, the main process can receive an update indicating an active vulnerability, and the main process can initiate if idle.

Referring to FIG. **8**, an embodiment of a method **800** of self-tuning a network intrusion, detection and prevention system is shown. In some embodiments, the network security tool **120**, or one or more components, modules, or processors thereof, can be designed, constructed or configured to perform one or more steps of process **800**. In some embodiments, method **800** may be performed at, during, or in associated with step **425** shown in FIG. **4**. In some embodiments, FIG. **8** can represent an illustrative sequence diagram that results in initiating, reinitiating or restarting the optimization process shown in FIG. **4**.

In some embodiments, at step **805**, the main process can initiate if idle, generate an alert, or reinitiate if idle (e.g., as shown at step **425** in FIG. **4**). At step **810**, the tool can determine that an active vulnerability exists and identify a corresponding exploit and signature. At step **815**, the tool can enable the signature in an intrusion detection and prevention system (IDS/IPS). Thereafter, the tool may return to an idle state and await a further update.

Referring to FIG. **9**, an illustrative embodiment of a method **900** of mitigating intrusions using a network security tool. In brief overview, and in some embodiments, the tool identifies a current vulnerability of a private network at step **905**. At step **910**, the tool determines a signature of an attack configured to exploit the vulnerability (e.g., signature of the exploit). At step **915**, the tool compares the signature of the exploit with active and inactive signatures stored in a signature repository. At step **920**, the tool automatically activates the signature of the exploit responsive to determining that the signature was inactive. At step **925**, the tool uses the activated signature to detect or identify an attack exploiting the vulnerability.

In further detail, at step **905**, the tool identifies a current vulnerability of a private or protected network. The tool may use a vulnerability assessment tool to identify current vulnerabilities. The tool may receive a current vulnerabilities list from a vulnerability assessment tool. In some embodiments, the tool may receive or access a current vulnerabilities list in a current vulnerabilities database. The current vulnerabilities may be determined by analyzing network traffic, TCP traffic, aggregated activities logs, etc. The tool can identify one or more vulnerabilities at step **905**. The vulnerabilities may be of the private network or one or more device, node, router, software, operating system or database associated with or connected to the private network, or otherwise using the private network.

At step **910**, the tool determines a signature of an attack configured to exploit the vulnerability (e.g., signature of the exploit). In some embodiments, a vulnerability assessment tool can identify the signature of the exploit for the current vulnerability. The tool can identify the signature by performing a lookup in one or more databases, or using one or more signature identification techniques or pattern recognition techniques. The tool can identify the vulnerability or signature based on a common scheme or standard. In some embodiments, the tool can identify several signatures of attacks that are configured to exploit the vulnerability or multiple vulnerabilities. In some embodiments, the tool can use a using a fuzzy logic algorithm to determine the signature of the attack configured to exploit the current vulnerability. For example, the tool can employ approximate reasoning using fuzzy logic variables that have truth values that range in degree between 0 and 1 in order to identify a signature or pattern of an attack configured to exploit a vulnerability.

At step **915**, the tool compares the signature of the exploit with active and inactive signatures stored in a signature repository. In some embodiments, the tool may compare signatures that are in a common scheme or standard. In some embodiments, comparing signatures may include performing a lookup in a repository, a matching technique, a comparison technique, or other technique used to identify a matching signature. In some embodiments, the signatures may be tagged with metadata or other identifiers (e.g., alphanumeric, numeric, characters, strings, text, symbols, etc.) that identify a signature, and comparing signatures may include comparing the identifiers (e.g., unique identifier for each signature of an exploit).

Upon identifying a match, the tool may determine whether the matching signature is active or inactive. For example, a first repository may include active signatures and a second repository may include inactive signatures, in which case the status of a signature may be determined based on which repository was searched. In another example, a signature may be tagged with a status indicating whether the signature is active or inactive. For example, a data file storing the signature may include status information, identifying information or other information of the signature. In some embodiments, the data file storing the signature may include historical status information, such as time or date information indicative of when the signature was last active, or each time the signature was active or inactive, a duration of activity, associated vulnerabilities, exploits, network configurations, devices, operating systems, etc.

If the tool determines that the current vulnerability corresponds to an inactive signature, at step **920**, the tool automatically activates the signature of the exploit responsive to determining that the signature was inactive. Activating the signature may include altering or updating a status of the signature from inactive to active, or providing the signature to an active signature repository, or providing the signature to an IDS/IPS system.

At step **925**, the tool uses the activated signature to detect or identify an attack exploiting the vulnerability. For example, the tool can use an intrusion detector or IDS/IPS system to analyze network traffic, data packets, TCP packets, etc. to identify a traffic pattern or data that corresponds to the active signature in order to mitigate or prevent the attack.

FIGS. **10** and **11** refer to illustrative implementations of a system including a network security tool. In the illustrative implementation shown in FIG. **10**, the system **1000** includes a self-tuning fuzzy logic device. The self-tuning fuzzy logic device may include one or more functionality of the network security tool **120**, or the network security tool **120** may include one or more functionality of the self-tuning fuzzy logic device of system **1000**. The device can include a self-tuning fuzzy logic process that performs one or more function as shown in optimization process **400** of FIG. **4**. For example, the device can include databases storing vulnerabilities, exploits, and signatures, and access same.

In some embodiments, the signature based network security appliance (IDP) can be external to the device. For example, the self-tuning fuzzy logic device, or network security tool **120** of FIG. **2**, can be a separate device from the IDPS.

In the illustrative implementation shown in FIG. **11**, the system **1100** includes a self-tuning fuzzy logic device or network security tool. Further, the system **1100** includes a protected or private network. Included in this private network is a third party vulnerability assessment tool (active or passive) and a third party log management system or a security information and event manager (SIEM). An SIEM may refer to software and products services combining security information management (SIM) and security event management (SEM). SIEM technology can provide real-time analysis of security alerts generated by network hardware and applications. SIEM may include software, appliances or managed services, and can log security data and generate reports for compliance purposes. Further, in system **1100**, the network security appliance (IDP) is also separate from the self-tuning fuzzy logic device or network security tool, similar to system **1000**. In various embodiments, the system **200** shown in FIG. **2** can include one or more components or configurations as shown in systems **1000** and **1100** of FIGS. **10** and **11**, respectively.

Thus, and in some embodiments, the tool can provide real-time automatic tuning of the IDP/IDS line of defense of a system/network. The tool can automatically tune a signature repository of the IDP/IDS line of defense based on the latest vulnerability profile of the protected system as it is formed by the results of vulnerability assessment and evolved passively by the feedback mechanism. The tool provides a smart, custom, and automatic process that brings the VA and IDP/IDS worlds in convergence. The tool provides a dynamic, recurring, fully automated IDS/IPS tuning process that also supports alerting capabilities in case that there are vulnerabilities that are not mapped to signatures, as well as, the potentiality for generation of new signatures. The tool leverages a passive vulnerability assessment process that runs along with the operation of the assessed system or protected network with dynamic and constant update of vulnerability intelligence.

While the invention has been particularly shown and described with reference to specific embodiments, it should be understood by those skilled in the art that various changes in form and detail may be made therein without departing from the spirit and scope of the invention described in this disclosure.

What is claimed is:

1. A method of mitigating intrusions via a computer network, comprising:

identifying, by a vulnerability assessment tool, a current vulnerability of a private network;

determining, by the vulnerability assessment tool, a signature of an attack configured to exploit the current vulnerability;

comparing, by a network security device, the signature with active and inactive signatures stored in a signature repository to identify an inactive signature corresponding to the signature of the attack configured to exploit the current vulnerability, the inactive signature previously activated and used by the network security device to detect exploits;

automatically activating, by the network security device responsive to the comparison, the identified inactive signature; and

using, by an intrusion detector, the activated signature to analyze data packets received via the private network to detect an exploit.

2. The method of claim **1**, further comprising:

identifying, by the vulnerability assessment tool, a second active signature stored in the signature repository;

obtaining, by the network security device, a plurality of signatures corresponding to one or more active vulnerabilities of the private network;

automatically deactivating, by the network security device, the second active signature responsive to the second signature being absent from the plurality of signatures corresponding to the one or more active vulnerabilities of the private network.

3. The method of claim **1**, further comprising:

continuously monitoring network traffic of the private network via one or more activity logs;

identifying, based on the monitoring, a second current vulnerability of the private network;

determining a second signature of a second attack configured to exploit the second current vulnerability;

comparing the second signature with the active and inactive signatures stored in the signature repository;

determining, based on the comparison, that the second signature corresponds to an active signature stored in the signature repository; and

using, by the intrusion detector, the active signature corresponding to the second signature to identify a second exploit based on data packets received via the private network.

4. The method of claim **1**, further comprising:

identifying a plurality of current vulnerabilities of the private network;

identifying a plurality of signatures corresponding to the plurality of current vulnerabilities;

comparing the plurality of signatures with the active and inactive signatures stored in the signature repository;

automatically activating, responsive to the comparison, inactive signatures stored in the signature repository that correspond to the plurality of signatures; and

automatically deactivating, responsive to the comparison, active signatures stored in the signature repository that do not correspond to the plurality of signatures.

5. The method of claim **1**, further comprising:

receiving an indication that the current vulnerability is resolved; and

automatically deactivating, responsive to the indication, the signature corresponding to the current vulnerability.

6. The method of claim **1**, further comprising:

using a fuzzy logic algorithm to determine the signature of the attack configured to exploit the current vulnerability.

7. The method of claim **1**, further comprising:

identifying a second current vulnerability of the private network;

determining a second signature of a second attack configured to exploit the second current vulnerability;

comparing the second signature with the active and inactive signatures stored in the signature repository;

determining, based on the comparison, that the second signature does not correspond to active or inactive signatures stored in the signature repository; and

automatically generating, based on the comparison, a new signature based on the second signature; and

activating and storing the new signature in the signature repository for use by the intrusion detector.

8. The method of claim **1**, wherein the signature comprises an attack pattern.

9. The method of claim **1**, further comprising:

receiving a plurality of logs of network activity associated with computing devices of the protected network; and

determining, based on the plurality of logs, a pattern indicative of a signature of an attack.

10. The method of claim **1**, further comprising:

monitoring, by the intrusion detector, the data packets of the private network to identify the exploit based on the active signature corresponding to the second signature;

responsive to identifying the second exploit, generating an alert; and

providing the alert to an administrator device of the private network.

11. The method of claim **1**, further comprising:

obtaining, via a public network, updates on current vulnerabilities established by a plurality of users of the public network.

12. A system for mitigating intrusions via a computer network, comprising:

a vulnerability assessment tool configured to identify a current vulnerability of a private network and determine a signature of an attack configured to exploit the current vulnerability;

a network security device configured to:

compare the signature with active and inactive signatures stored in a signature repository to identify an inactive signature corresponding to the signature of the attack configured to exploit the current vulnerability, the inactive signature previously activated and used by the network security device to detect exploits;

automatically activate, responsive to the comparison, the identified inactive signature; and

deactivate, responsive to the comparison, an active signature stored in the signature repository that does not correspond to the signature of the attack configured to exploit the current vulnerability; and an intrusion detector configured to use the activated signature to identify an exploit based on data packets received via the private network.

13. The system of claim **12**, wherein:

the vulnerability assessment tool is further configured to identify a second current vulnerability of the private network and determine a second signature of a second attack configured to exploit the second current vulnerability;

the network security device is further configured to:

compare the second signature with the active and inactive signatures stored in the signature repository;

determine, based on the comparison, that the second signature corresponds to an active signature stored in the signature repository; and

the intrusion detector is further configured to use the active signature corresponding to the second signature to identify a second exploit based on data packets received via the private network.

14. The system of claim **12**, wherein:

the vulnerability assessment tool is further configured to identify a plurality of current vulnerabilities of the private network and identify a plurality of signatures corresponding to the plurality of current vulnerabilities; and

the network security device is further configured to:

compare the plurality of signatures with the active and inactive signatures stored in the signature repository;

automatically activate, responsive to the comparison, inactive signatures stored in the signature repository that correspond to the plurality of signatures; and

automatically deactivate, responsive to the comparison, active signatures stored in the signature repository that do not correspond to the plurality of signatures.

15. The system of claim **12**, further configured to:

receive an indication that the current vulnerability is resolved; and

automatically deactivate, responsive to the indication, the signature corresponding to the current vulnerability.

16. The system of claim **12**, wherein the vulnerability assessment is further configured to:

use a fuzzy logic algorithm to determine the signature of the attack configured to exploit the current vulnerability.

17. The system of claim **12**, wherein:

the vulnerability assessment tool is further configured to identify a second current vulnerability of the private network and determine a second signature of a second attack configured to exploit the second current vulnerability; and

the network security device is further configured to:

compare the second signature with the active and inactive signatures stored in the signature repository;

determine, based on the comparison, that the second signature does not correspond to active or inactive signatures stored in the signature repository; and

automatically generate, based on the comparison, a new signature based on the second signature; and

activate and store the new signature in the signature repository for use by the intrusion detector.

18. The system of claim **12**, wherein the signature comprises an attack pattern.

19. The system of claim **12**, wherein the vulnerability assessment tool is further configured to:

receive a plurality of logs of network activity associated with computing devices of the protected network; and

determine, based on the plurality of logs, a pattern indicative of a signature of a attack.

20. The system of claim **12**, wherein the intrusion detector is further configured to:

monitor the data packets of the private network to identify the exploit based on the active signature corresponding to the second signature;

responsive to identifying the second exploit, generate an alert; and

provide the alert to an administrator device of the private network.

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